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Indian Standard

SAFETY REQUIREMENTS FOR ELECTRONIC FLASH APPARATUS FOR PHOTOGRAPHIC PURPOSES

UDC 771·448·6 : 614·8

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 14

December 1988

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Indian Standard

SAFETY REQUIREMENTS FOR ELECTRONIC FLASH APPARATUS FOR PHOTOGRAPHIC PURPOSES

National Foreword

This Indian Standard, which is identical with IEC Pub 491 (1984) 'Safety requirements for electronic flash apparatus for photographic purposes', issued by the International Electrotechnical Commission (IEC), was adopted by the Bureau of Indian Standards on the recommendations of the Radio Communications Sectional Committee and approval of the Electronics and Telecommunication Division Council.

In the adopted standard certain terminology and conventions are not identical with those used in Indian Standards; attention is specially drawn to the following:

a) Comma (,) has been used as decimal marker while in Indian Standards the current practice is to use a point (·) as the decimal marker.

b) Wherever the words 'International Standard' appear, referring to this standard, they should be read as 'Indian Standard'.

c) For the purpose of the Indian Standard, only the metric dimensions are applicable.

Cross Reference

International Standard	*Corresponding Indian Standard*
IEC Pub 27 Letter symbols to be used in electrical technology	IS : 3722 Letter symbols and signs used in electrical technology (*series*)
IEC Pub 68-2-2 (1974) Basic environmental testing procedures, Part 2: Tests — Tests B: Dry heat	IS : 9000 Basic environmental testing procedures for electronic and electrical items: Part 3 Dry heat test
IEC Pub 68-2-3 (1969) Test Ca: Damp heat, steady state	IS : 9000 (Part 4)-1979 Basic environmental testing procedures for electronic and electrical items: Part 4 Damp heat (steady state)
IEC Pub 68-2-6 (1982) Test Fc and guidance: Vibration (sinusoidal)	IS : 9000 (Part 8)-1981 Basic environmental testing procedures for electronic and electrical items: Part 8 Vibration (sinusoidal) test
IEC Pub 83 (1975) Plugs and socket-outlets for domestic and similar general use standards	IS : 1293-1967 Three-pin plugs and socket outlets (*first revision*)
IEC Pub 167 (1964) Methods of test for the determination of the insulation resistance of solid insulating materials	IS : 2259-1963 Methods of test for determination of insulation resistance of solid insulating materials
IEC Pub 227-2 (1979) Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V, Part 2 Test methods	IS : 694-1977 PVC insulated cables for working voltages up to and including 1 100 volts (*second revision*)
IEC Pub 245 Rubber insulated cables of rated voltages up to and including 450/750 V	IS : 9968 Elastomer insulated cables (*series*)

Radio Communications Sectional Committee, LTDC 20; Panel for Safety Requirements for Entertainment Electronic Equipment, LTDC 20/P5 [Ref : Doc : LTDC 20 (1276)]

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IEC Pub 249-1 (1982) Base materials for printed circuits, Part 1 Test methods	IS : 5921 (Part 1)-1983 Metal-clad base material for printed circuits for use in electronic and telecommunication equipment: Part 1 General requirements and tests (*first revision*)
IEC Pub 260 (1968) Test enclosures of non-injection type for constant relative humidity	IS : 9002 (Part 6)-1980 Equipment for environmental tests for electronic and electrical items: Part 6 Constant relative humidity chamber (non-injection type)
IEC Pub 317 Specification for particular types of winding wires	IS : 4800 Enamelled round winding wires (*series*)
IEC Pub 320 (1981) Appliance couplers for household and similar general purposes	IS : 3010 Appliance-connectors and appliance inlets (non-reversible three-pin type) (*series*)
IEC Pub 417 (1973) Graphical symbols for use on equipment. Index, survey and compilation of the single sheets	IS : 2032 Graphical symbols used in electrotechnology (*series*)
IEC Pub 536 (1976) Classification of electrical and electronic equipment with regard to protection against electric shock	IS : 9409-1980 Classification for electrical and electronic equipment with regard to protection against electric shock
IEC Pub 598-2-9 (1970) Luminaires, Part 2 Particular requirements, Section 9 — Photo and film luminaires (non-professional)	IS : 10322 Luminaires (*series of 6 standards*)
IEC Pub 664 (1980) Insulation coordination within low-voltage systems including clearances and creepage distances for equipment	SP 39 Insulation coordination within low voltage systems including clearances and creepage distances for equipment (*under print*)

The Radio Communications Sectional Committee has reviewed the provisions of the following IEC Publications and has decided that they are acceptable for use in conjunction with this Indian Standard:

IEC Pub 127 (1974)	Cartridge fuse-links for miniature fuses
IEC Pub 173 (1964)	Colours of the cores of flexible cables and cords
IEC Pub 227-1 (1979)	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V, Part 1: General requirements
IEC Pub 249-2 (1970)	Base materials for printed circuits, Part 2: Specifications
IEC Pub 799 (1984)	Cord sets
ISO 306-1974	Plastics — Determination of the Vicat softening temperature of thermo-plastics

1. Scope

1.1 This standard applies to the following electronic flash apparatus for photographic purposes, having a stored energy not exceeding 2 000 J, together with associated apparatus and not intended to be subjected to dripping or splashing:

— apparatus of the single-flash type which can have more than one flash head operating at the same time;

— apparatus for the illumination of sequential photographic exposures;

— battery chargers and supply units to be used in connection with electronic flash apparatus for photographic purposes. These auxiliary units may form a part of the mains plug;

— accessories, such as light regulators and slave units, specified in the instruction leaflet.

This standard does not apply to stroboscopes.

As long as no appropriate requirements exist for apparatus having a stored energy exceeding 2 000 J, this standard may be used, in so far as it is applicable.

Additional requirements may be necessary, e.g. for explosion and thermal radiation.

With regard to the supply, the following categories are covered:

— mains-operated apparatus;

— battery-operated apparatus;

— apparatus having a combination of mains and battery supply.

This standard is intended to cover apparatus which can be used both in moderate and tropical climates.

For the modelling lamps combined with electronic flash apparatus for photographic purposes, additional requirements may be taken from I E C Publication 598-2-9: Luminaires, Section Nine Photo and Film Luminaires (Non-professional), as far as applicable.

1.2 This standard does not apply to apparatus designed for a rated supply voltage exceeding 250 V (r.m.s.) against earth.

1.3 This standard is concerned with safety only and not with the other properties of the apparatus (see Clause 3).

2. Definitions

The following definitions apply for the purpose of this standard:

2.1 The *type test* of a product is the complete series of tests to be carried out on a number of specimens representative of the type, with the object of determining whether a particular manufacturer can be considered to be able to produce products meeting the standard.

2.2 *By hand* denotes that the operation does not require the use of a tool, coin or any other object.

2.3 *Accessible part* denotes a part which can be touched by the standard test finger (see Sub-clause 8.1.1).

Any accessible area of a non-conducting part is considered as being covered with a conductive layer (see Sub-clause 4.3.1).

2.4 *Live part* denotes a part, contact with which may cause a significant electric shock (see Sub-clause 8.1.1).

2.5 *Creepage distance* denotes the shortest distance along the surface of an insulation material between two conductive parts. (According to I E C Publication 664: Insulation Co-ordination within Low-voltage Systems Including Clearances and Creepage Distances for Equipment.)

2.6 *Clearance* denotes the shortest distance in air between two conductive parts.

2.7 *Supply mains* denotes any power source with an operating voltage of more than 34 V (peak) which is not used solely to supply the equipment specified in Sub-clause 1.1.

2.8 *Rated supply voltage* denotes the mains voltage for which the manufacturer has designed the apparatus.

2.9 *Part directly connected to the supply mains* denotes a part of an apparatus which is in electrical connection with the supply mains in such a way that a connection between the part and either pole of the supply mains causes in that connection a current equal to or greater than 9 A.

A current of 9 A is chosen as the minimum rupturing current of a 6 A fuse.

In tests to determine which parts are directly connected to the supply mains, fuses in the apparatus are not short-circuited.

2.10 *Part conductively connected to the supply mains* denotes a part of an apparatus which is in electrical connection with the supply mains in such a way that a connection through a resistance of 2 000 Ω between the part and either pole of the supply mains causes in that resistance a current greater than 0.7 mA (peak), the apparatus not being connected to earth.

2.11 *Supply unit* denotes an apparatus which takes energy from the mains and from which one or more other apparatus are fed.

2.12 *Battery charger* denotes an apparatus which is directly fed from the supply mains and which provides energy in the form necessary to charge a battery.

2.13 *Terminal device* denotes a part of an apparatus by which connection is made to external conductors or other apparatus; it may contain several terminal contacts.

2.14 *Thermal release* denotes a device which prevents the maintenance of excessively high temperatures in certain parts of the apparatus by disconnecting those parts from their supply.

2.15 *Safety switch* denotes a device which interrupts the supply when a cover is opened.

2.16 *Printed board* denotes a base material cut to size, containing all holes and bearing at least one conductive pattern.

2.17 *Conductive pattern* denotes a configuration formed by electrically conductive material of a printed board.

2.18 *Class I apparatus* denotes an equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in such a way that means are provided for the connection of accessible conductive parts to the protective (earthing) conductor in the fixed wiring of the installation in such a way that accessible conductive parts cannot become live in the event of a failure of the basic insulation.

Such apparatus may have parts consisting of Class II construction.

2.19 *Class II apparatus* denotes an equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation, are provided, there being no provision for protective earthing or reliance upon installation conditions.

2.20 *Basic insulation* denotes an insulation applied to live parts to provide basic protection against electric shock.

2.21 *Supplementary insulation* denotes an independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of the basic insulation.

2.22 *Double insulation* denotes an insulation comprising both basic insulation and supplementary insulation.

2.23 *Reinforced insulation* denotes a single insulation system applied to live parts which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in this standard.

The term "insulation system" does not imply that the insulation should be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.

The definitions given in Sub-clauses 2.18 to 2.23 are according to I E C Publication 536: Classification of Electrical and Electronic Equipment with Regard to Protection against Electric Shock.

3. General requirements

The apparatus shall be so designed and constructed as to present no danger, either in normal use or under fault conditions, providing particularly:

- personal protection against electric shock;
- personal protection against the effects of excessive temperature;
- protection against fire.

In general, compliance is checked under normal operating conditions and under fault conditions specified in Sub-clauses 4.2 and 4.3, by carrying out all the tests indicated.

4. General conditions for tests

4.1 *Conduct of tests*

4.1.1 *Tests according to this standard are type tests.*

4.1.2 *All tests are carried out on one and the same apparatus and in the order of the clauses as far as this is possible.*

4.1.3 *Unless otherwise specified, tests are made under normal operating conditions at an ambient temperature within the range of 15 °C to 35 °C, a relative humidity of 45% to 75% and an air pressure of 860 mbar to 1 060 mbar.*

4.1.4 *Unless otherwise specified:*

- *waveforms are substantially sinusoidal;*
- *measurements of voltages and currents are carried out with instruments which do not appreciably affect the values to be measured.*

4.1.5 *Test requirements are based on the use of fully charged rechargeable batteries or dry batteries in a fresh condition.*

4.2 *Normal operating conditions*

Normal operating conditions are considered to consist of the most unfavourable combination of the following conditions:

4.2.1 *Any position of normal use of the apparatus.*

4.2.2 *A supply voltage of 0.9 times or 1.1 times any rated supply voltage for which the apparatus is set.*

For apparatus having a rated supply voltage range not requiring the adjustment of a voltage setting device, a supply voltage of 0.9 times the lower limit or 1.1 times the upper limit of the rated supply voltage range; if considered necessary, a supply voltage of 0.9 times or 1.1 times a nominal supply voltage within the range marked on the apparatus.

Any rated frequency of the supply voltage.

For battery-operated apparatus, the specified battery in a fully charged state or in fresh condition.

The apparatus operated on each type of supply for which it is designed.

4.2.3 *Any position of controls which are accessible to the user for adjustments by hand, except voltage setting devices complying with Sub-clause 13.6.*

4.2.4 *Connection or not of flash heads, capacitors and other accessories.*

4.2.5 *Apparatus which can be used either while connected to the mains or with its own supply connected to the mains or not.*

4.2.6 *Any protective earth terminal being connected to earth or not, and either pole of the isolated supply source, used during the test, being earthed.*

4.3 *Fault conditions*

Operation under fault conditions denotes that, in addition to the normal operating conditions mentioned in Sub-clause 4.2, each of the following conditions is applied in turn and, associated with it, those other fault conditions which are a logical consequence.

Examination of the apparatus and its circuit diagram will generally show the fault conditions which should be applied. These are applied in sequence in the order which is most convenient.

4.3.1 *Short-circuit across creepage distances and clearances if they are less than the values indicated by curve A in Table I.*

If an insulating part contains a groove of less than 1 mm width, the creepage distance is not measured over the surface of the groove but only across its width.

If a clearance consists of two or more air gaps in series separated by conductive parts, any gap of less than 1 mm width is ignored in computing the total distance unless the total distance as required in Table I is less than 1 mm. However, individual gaps of less than 0.5 mm are ignored.

This does not imply that dimensional requirements of insulations specified in Sub-clauses 8.3.7 and 8.3.8 can be ignored.

If an insulating barrier consists of two parts separated by a capillary slit, the path along the slit should be taken into account when measuring creepage distances and clearances.

The specified creepage distances and clearances are the minimum actual separations taken into account tolerances in assemblies and piece parts.

Guidance for the determination of creepage distances and clearances involving enamelled wires is given in Sub-clause 4.3.3.

In the determination of creepage distances and clearances between accessible parts and live parts, when using the standard test finger, any accessible zone of a non-conductive part is considered as being covered with a conductive layer (see Figure 1, page 90, as an example).

The voltages mentioned in Table I are determined with the apparatus connected to the rated supply voltage after the steady state has been reached.

Creepage distances and clearances are measured with conductors and plugs in their normal positions.

Between conductors, one of which may be directly or conductively connected to one pole of the supply mains, which are on a printed board complying with the pull-off and peel strength requirements specified in IEC Publication 249-1, Base Materials for Printed Circuits, Part 1: Test methods and IEC Publication 249-2: Part 2: Specifications, the requirements for creepage distances and clearances are modified.

The dimensions of Table I are replaced by the values calculated from the formula:

$$\log d = 0.78 \log \frac{\hat{U}}{300}\text{, with a minimum of 0.5 mm.}$$

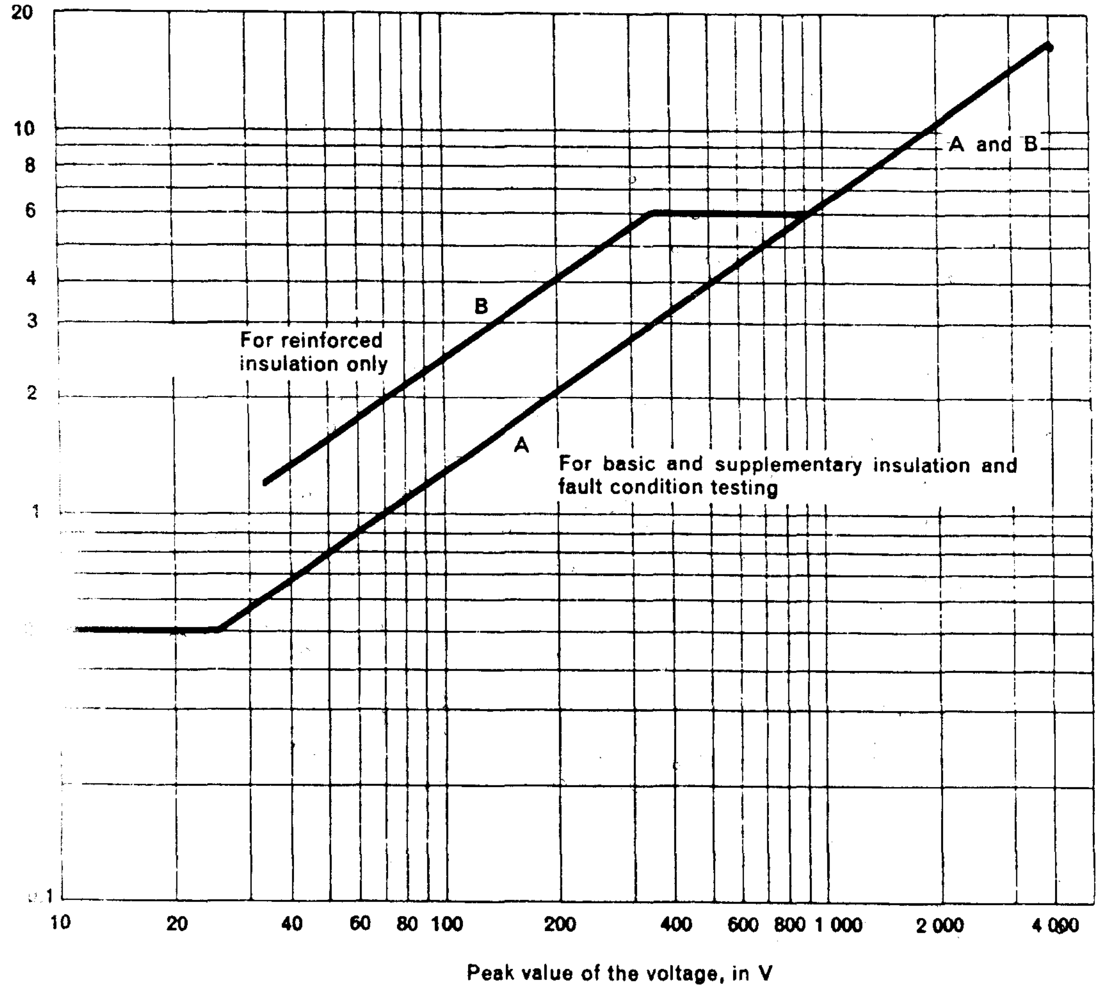
where d is the distance in millimetres and $\hat{U}$ the peak value of the voltage in volts. These distances can be determined by reference to Figure 7, page 97.

This reduction in creepage distances and clearances is permitted only as far as overheating is concerned (see Sub-clause 10.2).

The reduced values above apply to the conductors themselves, but not to mounted components or associated soldering terminals.

Coverings of lacquer or the like on printed boards are ignored when calculating the distances.

TABLE I



For parts conductively connected to the supply mains with voltages in the range of 220 V to 250 V (r.m.s.), the dimensions are equal to those related to 354 V peak.

For voltages over 4 000 V peak, the voltage test is used to determine whether the creepage distances or clearances shall be short-circuited or not (see Sub-clause 9.2).

A voltage across the basic insulation is determined by short-circuiting the supplementary insulation and vice versa.

The graphs of Table I are defined by the following:

Curve A: 34 V corresponds to 0.6 mm
354 V corresponds to 3.0 mm

Curve B: 34 V corresponds to 1.2 mm
354 V corresponds to 6.0 mm

Under certain conditions, the distances may be reduced as given in Sub-clauses 4.3.3 and 8.3.5.

4.3.2 *Short-circuit across or, if applicable, interruption of semiconductor devices and interruption of filaments of lamps.*

Short and open circuiting of glow-discharge lamps (used for indication or regulation).

4.3.3 *Short-circuit across insulation consisting of covering of lacquer, enamel or textile. Such coverings are ignored in assessing the creepage distances and clearances specified in Table I. However, if enamel forms the insulation of a wire and withstands the voltage test prescribed for Grade 2 in Clause 13 of IEC Publication 317: Specifications for Particular Types of Winding Wires, it is considered as contributing 1 mm to those creepage distances and clearances.*

This sub-clause does not imply a need to short-circuit the insulation between turns of coils, insulating sleeves or tubings.

4.3.4 *Short-circuit across electrolytic capacitors.*

4.3.5 *Short-circuit across insulating parts, the short-circuiting of which might cause an infringement of the requirements regarding protection against electric shock or overheating, with the exception of insulating parts which comply with the requirements of Sub-clause 9.2.*

4.3.6 *Short-circuit or disconnection, whichever is more unfavourable, of capacitors, resistors or inductors other than transformers and motors, the short-circuiting or disconnection of which might cause an infringement of the requirements regarding protection against electric shock or overheating.*

These fault conditions do not apply to:

a) resistors complying with the requirements of Sub-clauses 10.2 and 13.1

b) inductors complying with the requirements of Sub-clause 13.8.1

c) capacitors complying with the requirements of Sub-clause 13.2, provided that the voltage at their terminals does not exceed 354 V (peak)

Requirements for capacitors which need not be short-circuited or disconnected when checking the protection against overheating are under consideration.

d) self-healing capacitors (e.g. of the metallized paper type) as far as overheating is concerned.

In order to determine which are the insulating parts and the components (see Sub-clauses 4.3.5 and 4.3.6), the short-circuiting or disconnection of which might cause an infringement of the requirements regarding protection against electric shock or overheating, the apparatus is inspected and its circuit diagram is studied.

4.3.7 *Loosening, by a quarter of a turn, unlocked screws or similar devices which are used for fixing covers over live parts.*

4.3.8 *For battery chargers and supply units: connection of the most unfavourable load impedance to the output terminals, including short circuit.*

4.3.9 *For battery chargers and supply units: connection to a supply voltage of 250 V a.c., independent of the rated supply voltage or voltages of the charger or unit and with the voltage setting device, if any, set at the most unfavourable position.*

4.3.10 *Stopping of forced cooling.*

4.3.11 *Locking of moving parts of apparatus provided with:*

- *motors having a locked rotor torque smaller than the full load torque;*
- *motors with moving parts which can be jammed by mechanical failures or by handling of the equipment, if such a failure or handling is probable.*

4.3.12 *Continuous operation of motors, relay coils or the like, intended for short-time or intermittent operation, if continuous operation may occur accidentally.*

5. Marking

5.1 *General*

The apparatus shall be marked in accordance with the requirements of Sub-clauses 5.2 and 5.3.

The marking shall be:

- easily discernible on the apparatus when ready for use, in such a way that there can be no misunderstanding;
- indelible and legible.

Compliance is checked by inspection and by the following test.

The marking shall not be removed when rubbed lightly with a piece of cloth soaked with petroleum spirit or water.

The information should preferably be put on the exterior of the apparatus. It is, however, permissible to put it on another place that is easily accessible by hand, provided that the location of the marking is given in the instructions for use.

Letter symbols for quantities and units shall be in accordance with IEC Publication 27: Letter Symbols to be Used in Electrical Technology.

Graphical symbols shall be in accordance with IEC Publication 417: Graphical Symbols for Use on Equipment. Index, Survey and Compilation of the Single Sheets.

Fuse holders shall be marked in accordance with Sub-clause 13.3.2.

Mains switches shall be marked in accordance with Sub-clause 13.4.3.

Compliance is checked by inspection.

5.2 *Identification*

The apparatus shall be identified by:

a) manufacturer's name or registered trade mark·
b) model number or name.

Compliance is checked by inspection.

It is not prohibited to mark Class II apparatus with the double square symbol ⧈ (417-IEC-5172).

This symbol shall be so placed that it will be obvious that it is a part of the technical information and is unlikely to be confused with the maker's name or trade mark.

5.3 *Supply*

The apparatus shall be marked with the following information:

a) Nature of supply:

- a.c. only with the symbol ∼;
- d.c. only with the symbol — or ⎓ (for battery apparatus only).

b) Rated supply voltage or range of the rated supply voltages which can be applied without operating a voltage setting device, unless the apparatus is supplied from a separate supply unit only.

c) Apparatus which can be set to different rated supply voltages shall be so constructed that the indication of the voltage to which the apparatus is set is discernible on the apparatus when ready for use. If the apparatus is so constructed that the user can alter the supply voltage setting, the action of changing the setting shall change also the indication.

For battery chargers and supply units which form part of a mains plug, it is permitted that the indication of the voltage to which the apparatus is set is on the engagement face of the plug.

d) Rated mains frequency (or range of frequencies) in hertz, if safety is dependent on the use of the correct mains frequency.

Compliance is checked by inspection.

5.4 *Instructions for use*

5.4.1 Battery chargers and supply units shall be accompanied by an instruction leaflet in which shall be indicated the type of flash apparatus with which it is to be used.

The flash apparatus shall be accompanied by an instruction leaflet in which shall be indicated the type of supply unit or battery charger with which it is to be used.

It is also permitted to give this information on the devices themselves.

Compliance is checked by inspection.

5.4.2 The instructions for use shall state that the apparatus shall not be exposed to dripping or splashing.

Compliance is checked by inspection.

5.4.3 The instructions for use shall contain a warning to the effect that:

- batteries shall not be exposed to excessive heat such as sunshine, fire or the like,

- dry batteries shall not be subjected to charging.

Compliance is checked by inspection.

5.5 *Terminal devices*

Terminal devices shall be marked with the following symbols:

a) protective earth terminal, if any: ⏚ (417-IEC-5019).

b) terminal devices which are live under normal operating conditions, with the exception of terminals for mains supply and mains socket-outlets: ϟ (417-IEC-5036).

The flash shall point to the terminal device.

This symbol may only be used to indicate the existence of a live terminal and may not be used to label non-live terminals for the purpose of avoiding more stringent insulation requirements.

Compliance is checked by inspection. The marking of a protective earth terminal need not be discernible from the outside (see Sub-clause 14.4).

For information purposes, it may be useful to mark apparatus suitable for both a.c. and d.c. with the symbol: ≂ (417-IEC-5033).

6. Heating under normal operating conditions

6.1 In normal use, no part of the apparatus shall attain an unsafe temperature.

Compliance is checked by monitoring the temperatures under the conditions specified below and immediately after they have been applied.

If the apparatus can be mains-operated, it is switched on for a period of 4 h without flashing; if only battery or rechargeable battery is supplied, it is switched on for 30 s.

Thereupon as many consecutive flashes as can be produced, with a maximum of 40, are made as quickly as possible. The rate of flashing is determined by the indicator or, if no indicator, by the measured voltage on the flash capacitors, which should be 85% of the maximum peak voltage. The apparatus is supplied at its rated voltage.

A battery charger is connected for 4 h to a fully discharged rechargeable battery for which the charger has been designed.

Temperatures are determined:

— *in the case of windings, by the resistance method;*

— *in other cases, by any other suitable method.*

Care should be taken that during the measurement of the resistance of windings, the influence of circuits or loads connected to these windings is negligible.

Temperature rises shall not exceed the values given in column I of Table II.

6.2 Insulating material supporting parts conductively connected to the supply mains shall be resistant to heat if, in normal use, these parts carry a current exceeding 0.5 A and might dissipate substantial heat due to imperfect contact.

In those cases where two groups of conductors, each supported by insulation parts, can be rigidly connected or joined together (e.g. by plug and socket), one only of the insulating parts shall meet the test. Where one of the insulating parts is fixed in the apparatus, this part shall meet the test.

Compliance is checked by subjecting the insulating material to the test specified under a) in Note 6 to Table II.

The softening temperature of the insulating material shall be at least 150 °C.

Examples of parts which might dissipate substantial heat in normal use are contacts of switches and of voltage adaptors, screw terminals and fuse holders.

TABLE II

Parts of the apparatus	*Permissible temperature rise K*	
	Normal operating conditions I	*Fault conditions* II
External parts		
Metal parts *knobs, handles, etc.*	30	65
enclosure (note 1)	40	65
Non-metallic parts *knobs, handles, etc. (note 2)*	50	65
enclosures (note 1, note 2)	60	65
Inside of enclosures of insulating material	*(note 3)*	*(note 3)*
Windings *(note 4)*		
Wires insulated with non-impregnated silk, cotton, etc.	55	75
Wires insulated with impregnated silk, cotton, etc.	70	100
Oleoresinous enamelled wires	70	135
Wires enamelled with polyvinylformaldehyde or polyurethane resins	85	150
Core laminations	*As for the relevant windings*	
Supply cords and wiring		
Insulated with ordinary polyvinyl chloride (note 8)		
not under mechanical stress	60	100
under mechanical stress	45	100
Insulated with natural rubber	45	100
Other insulations *(note 4, note 7) except thermoplastic*		
Non-impregnated paper	55	70
Non-impregnated cardboard	60	80
Impregnated cotton, silk, paper and textile, urea resins	70	90
Laminates, bonded with phenolformaldehyde resins, phenolformaldehyde mouldings with cellulose fillers	85	110
Phenolformaldehyde mouldings with mineral fillers	95	130
Laminates bonded with epoxy resins	120	150
Natural rubber	45	100
Thermoplastic materials *(note 5)*	*(note 6)*	

The values of the temperature rises are based upon a maximum ambient temperature of 35 °C, but the measurements are made under normal operating conditions.

Notes 1. — For areas having no dimension exceeding 5 cm and which are not likely to be touched in normal use, temperature rises up to 65 K are allowed under normal operating conditions.

*2. — **If these temperature rises are higher than those allowed by the class of the relevant insulating material, the nature of the material is the governing factor.***

3. — The permissible temperature rises for the inside of enclosures of insulating material are those indicated for the relevant materials.

4. — For the purpose of this standard, the permissible temperature rises are based on the recommendations in I E C Publication 85: Thermal Evaluation and Classification of Electrical Insulation. The materials quoted above are shown only as examples. If materials other than those listed in I E C Publication 85 are used, the maximum temperatures should not exceed those which have been proved to be satisfactory.

5. — Natural and synthetic rubbers are not considered as being thermoplastic materials.

6. — Due to their wide variety, it is not possible to specify permissible temperature rises for thermoplastic materials. While the matter is under consideration, the following method shall be used:

a) a softening temperature of the material is determined on a separate specimen, under the conditions specified in ISO Standard 306, modified as follows:

- *the depth of penetration is 0.1 mm;*
- *the total thrust of 10 N (1 kgf) is applied before the dial gauge is set to zero or its initial reading noted.*

b) the temperature limits to be considered for determining the temperature rises are:

- *under normal operating conditions, a temperature 10 °C lower than the softening temperature as obtained under a);*
- *under fault conditions, the softening temperature itself.*

7. — The table does not apply to materials used in the construction of resistors.

8. — The possibility of raising the values for wires and cables insulated with heat-resistant polyvinyl chloride is under consideration.

7. Resistance to deformation at elevated ambient temperatures

The enclosure of the apparatus shall be sufficiently resistant to deformation at elevated temperatures.

Compliance is checked by the following test.

The apparatus is subjected for a period of two days (48 h) to the test prescribed in I E C Publication 68-2-2: Basic Environmental Testing Procedures, Part 2, Tests — Tests B: Dry heat, Test Bb, at a temperature of 70 ± 2 °C.

After this treatment, the apparatus shall show no damage in the sense of this standard.

8. Shock hazard under normal operating conditions

8.1 *Testing on the outside*

8.1.1 General

Accessible parts and terminals for the connection to the synchronizer of the camera shall not be live.

In order to determine whether a part is accessible (see Sub-clause 2.3), the jointed test finger according to Figure 2a, page 91, or the rigid test finger according to Figure 2b, page 91, is applied in every possible position, in case of doubt with a maximum force of 30 N (3 kgf). The test is carried out on all outer surfaces.

The force shall be so exerted by the tip of the test finger as to avoid wedge or lever action.

A rigid test finger loaded as above should be applied around any opening, or at any place where deformation could cause an opening. At the same time, a jointed test finger is applied without force to determine if live parts have become accessible.

During the tests, the distances between accessible metal parts and live parts shall become not less than the values given in Table I, live parts shall not become accessible.

An electrical contact indication with a voltage of approximately 40 V is recommended to show contact with conductive parts.

In order to verify that a part or terminal contact is not live, the following measurements are carried out between any two parts or contacts, then between any part on terminal contact and either pole of the supply source.

The measurements are also carried out 2 s after withdrawal of plugs and/or connectors from the corresponding socket-outlets or connector sockets.

If possible, flashing is made during the measurements.

The part or terminal contact is not live if:
from each part or contact, the current measured through a non-inductive resistance of 50 000 Ω does not exceed 0.7 mA (peak) a.c. or 2 mA d.c. and moreover:

— *for voltages between 34 V (peak) and 450 V (peak), the capacitance does not exceed 0.1 μF,*

— *for voltages between 450 V (peak) and 15 kV (peak), the discharge does not exceed 45 μC.*

For frequencies above 1 kHz, the limit of 0.7 mA (peak) is multiplied by the value of the frequency in kilohertz, but shall not exceed 70 mA (peak).

The values indicated for the capacitances are rated values.

The test establishes that if the voltage at the part exceeds 34 V (peak) a.c. or 100 V d.c., the source impedance is such that a current greater than 0.7 mA (peak) a.c. or 2 mA d.c. cannot be drawn through a resistance of 50 000 Ω.

8.1.2 Operating shafts

Operating shafts shall not be live.

Compliance is checked by measurement.

8.1.3 Ventilation hole

Ventilation and other holes over live parts shall be so designed that a suspended foreign body (for example a necklace) introduced into the apparatus shall not come into contact with any live part.

Compliance is checked by inserting through the holes a metal test pin with a diameter of 4 mm and a length of 100 mm. The test pin is suspended freely from one end, the penetration being limited to its length. During the test, the apparatus is held in any position.

The test pin shall not become live.

8.1.4 Mains voltage adjustment

There shall be no risk of electric shock during the operation of changing the voltage, or nature of supply, either by hand or by a tool which does not involve the removal of a cover.

Compliance is checked by making the tests described in Sub-clause 8.1.1 or by a test made with the appropriate tool.

8.1.5 Withdrawal of mains plug

Apparatus intended to be connected to the supply mains by means of a mains plug shall be so designed that there is no risk of electric shock when touching the pins or contacts of the plug after its withdrawal from the socket-outlet.

Compliance is checked by the following test.

The apparatus is operated under normal operating conditions.

The mains switch, if any, is then moved to the off-position, unless it is more unfavourable to keep it in the on-position, and the apparatus is disconnected from the supply mains by means of the plug.

Two seconds after withdrawal of the plug, no pin shall be live, the measurement being made according to Sub-clause 8.1.1, between a pin and any other contact of the plug.

In order to reasonably cover the most unfavourable situation the test may be repeated up to ten times.

8.2 *Testing after removal of protective covers*

A part which is exposed by the removal by hand of a cover shall not be live.

Compliance is checked by application of the tests of Sub-clause 8.1.1.

Any removable part of a voltage setting device is considered to be a protective cover (see Sub-clause 8.3.1).

8.3 *Constructional requirements*

8.3.1 The insulation of live parts shall not be provided by hygroscopic materials, such as non-impregnated wood, paper and similar fibrous materials.

Compliance is checked by inspection and, in case of doubt, by the following test.

A specimen of the material, as specified in Clause 9 of IEC Publication 167: Methods of Test for the Determination of the Insulation Resistance of Solid Insulating Materials, is subjected to the test prescribed in IEC Publication 68-2-3: Part 2, Tests — Test Ca: Damp Heat, Steady State, (temperature 40 ± 2°C, relative humidity: 90% to 95%), the conditioning period being four days (96 h).

After this test, the specimen shall withstand the tests of Sub-clause 9.2.

If necessary, the test is made on more than one specimen.

8.3.2 The apparatus shall be so constructed that there is no risk of an electric shock from accessible parts or from those parts rendered accessible following the removal by hand of a cover. However, internal parts in a battery compartment which become accessible, either with or without a tool, when replacing the batteries, shall be insulated from live parts by at least basic insulation.

Apparatus having a stored energy not exceeding 150 J shall be of Class II construction (see Sub-clause 8.3.4).

For apparatus having a stored energy above 150 J, Class I and II construction is permitted.

Terminals for the connection to the synchronizer of the camera shall be insulated from live parts according to Sub-clause 8.3.4.

Compliance is met by either satisfying Sub-clause 8.3.3 or Sub-clause 8.3.4.

8.3.3 For Class I apparatus, the accessible metal parts (except for those parts of the apparatus which are of Class II, see Sub-clause 2.18) shall be separated from live parts by basic insulation meeting the requirements of Item *a)* of Sub-clause 8.3.4.

This requirement does not apply to insulation the short-circuiting of which does not cause any shock hazard e.g. if one end of a secondary winding of a separating transformer is connected to an accessible metal part, the other end need not meet any special insulation requirement with regard to the same accessible metal part.

Class I apparatus shall be provided with a protective earth terminal or contact to which accessible metal parts shall be reliably connected, except those insulated from live parts by insulation meeting the requirements of Sub-clause 8.3.4 or those which are protected from becoming live by a metal part reliably connected to the protective earth terminal.

Examples of such a metal part are a metal screen in a transformer between the primary and the secondary windings (see Sub-clause 13.8.3), a metal chassis, etc.

8.3.4 For Class II apparatus, the accessible parts shall be insulated from live parts either by double insulation specified under Item *a)* or by reinforced insulation specified under Item *b)*.

This requirement does not apply to insulations, the short-circuiting of which does not cause any shock hazard e.g. if one end of a secondary winding of a separating transformer is connected to an accessible metal part, the other end need not meet any special insulation requirement with regard to the same accessible metal part.

A component complying with the requirements of Sub-clauses 13.1 or 13.8 may bridge basic, supplementary, double or reinforced insulations. Basic and supplementary insulations may each be bridged by a capacitor complying with the requirements of Sub-clause 13.2.

Double or reinforced insulations may be bridged by a single capacitor complying with the requirements of Sub-clause 13.2 if an appropriate and reliable procedure is employed to check the uniformity and continued conformance to the relevant specification for the current production. Alternatively, two capacitors of the same nominal value in series, each complying with the requirements of Sub-clause 13.2, are required. Moreover, the external insulation of a capacitor of the insulated type shall not bridge reinforced insulation or double insulation used in the construction of the apparatus, unless the external insulation of this capacitor meets the requirements of Sub-clause 8.3.7.

a) If accessible parts are separated from live parts by basic insulation and supplementary insulation, the following shall apply.

Each of these insulations shall comply with the requirements of Clause 9 and with the requirements for creepage distances and clearances specified in Sub-clause 8.3.5. Internal insulations not complying with the requirements of Sub-clauses 8.3.6 and 8.3.7 or 8.3.8 are neglected when computing the creepage distances and clearances.

b) If accessible parts are separated from live parts by reinforced insulation, the following shall apply.
The insulation shall comply with the requirements of Clause 9. Moreover, it shall comply with the requirements for creepage distances and clearances specified in Sub-clause 8.3.5. Internal insulations not complying with the requirements of Sub-clauses 8.3.6 and 8.3.7 or 8.3.8 are neglected when computing the creepage distances and clearances.

An example of assessment of reinforced insulation is given in Figure 11, page 101.

8.3.5 Creepage distances and clearances shall be not less than the values indicated in Table I, except that they may be reduced by 1 mm if all the following three conditions are met:

- they are not between accessible metal parts of an enclosure and live parts, if such external forces, as can be expected in normal use, including transportation, may reduce them,
- they are maintained by rigid construction, and
- their insulation properties are not likely to be significantly affected by any deposition of conductive dust produced inside the apparatus, for example by the carbon brushes of commutator motors.

The minimum creepage distances and clearances shall not be reduced below two-thirds of the values given by the curves of Table I, after taking into account any reduction allowed for wire enamel according to Sub-clause 4.3.3, with a minimum of 0.5 mm for basic insulation and supplementary insulation, and with a minimum of 1 mm for reinforced insulation.

Compliance is checked by inspection and measurement.

The creepage distances and clearances are measured whilst a force of 2 N is applied to any live part (including live wires) and to any internal part connected to accessible parts (including wires connected to them) and at the same time a force of 50 N by means of the rigid test finger being applied to any point on the outside of the enclosure.

8.3.6 Insulating layers on live parts, or on the inside surface of accessible metal parts or on any other internal metal part, are deemed to provide adequate protection if they withstand the following three tests in the order given. Such layers may be used as reinforced insulation, provided that they are not under such mechanical stress which, at the normal operating temperature, would be likely to lead to deformation or deterioration of the insulating material.

Ageing test.

The coated part is subjected to the test prescribed in IEC Publication 68-2-2: at a temperature of 70 ± 2 °C and for a period of seven days (168 h).

After this treatment, the part is allowed to cool at room temperature and inspection shall show that the layer has not loosened or shrunk away from the base material.

Impact test.

The part is then conditioned, for a period of 4 h, at a temperature of −10 ± 2 °C.

While still at this temperature, the layer is subjected to a blow applied to any point of the layer that is likely to be weak, from a spring-operated impact hammer as shown in Figure 4, page 94.

After this test, the layer shall not be damaged; in particular, it shall show no cracks visible to the naked eye.

Scratch test.

Finally, the part at the highest temperature attained under normal operating conditions is subjected to a scratch test.

The scratches are made by means of a hardened steel pin, the end of which has the form of a cone having a top angle of 40°, its tip being rounded with a radius of 0.25 ± 0.02 mm.

Scratches are made by drawing the pin along the surface at a speed of about 20 mm/s as shown in Figure 5, page 95. The pin is so loaded that the force exerted along its axis is 10 ± 0.5 N. The scratches are at least 5 mm apart and at least 5 mm from the edge of the specimen.

After this test, the layer shall neither have loosened nor be pierced, and it shall withstand a dielectric strength test as specified in Sub-clause 9.2, the test voltage being applied between the base material and a metal foil in contact with the layer.

The tests may be made on a separate specimen of the coated part.

More stringent tests which are necessary for insulating layers on the outside of metal parts are under consideration.

8.3.7 *a)* The insulation between live conductors in wires or cables and accessible parts, or between live parts and conductors in wires or cables connected to accessible metal parts, shall have a thickness of at least 0.4 mm if made of polyvinyl chloride. Other materials are allowed provided that they withstand the dielectric strength test specified in Sub-clause 9.2 and that their thickness ensures an equivalent mechanical strength, where the construction so requires.

b) In Class II apparatus, double insulation shall be provided between accessible parts and conductors in wires or cables conductively connected to the supply mains. In the case of conductors in wires or cables connected to accessible metal parts, double insulation shall be provided between these conductors and parts conductively connected to the supply mains.
Either the basic insulation or the supplementary insulation shall have a thickness of at least 0.4 mm. The other insulation may be thinner, even if made of polyvinyl chloride, provided that it withstands the dielectric strength test specified in Sub-clause 9.2 for basic insulation or supplementary insulation.
If double insulation consists of two layers which cannot be tested separately, it shall withstand the dielectric strength test specified in Sub-clause 9.2 for reinforced insulation.

The enamel layer of a wire complying with IEC Publication 317, grade 2, is acceptable as one of the insulating layers, provided that the combination of the insulations withstands the dielectric strength test specified in Sub-clause 9.2 for reinforced insulation.

The test voltage of Sub-clause 9.2 is applied between the conductor and a metal foil wrapped tightly around the insulation of the wire over a length of 10 cm.

In the case of insulating sleeves, the test voltage of Sub-clause 9.2 is applied between a metal rod inserted into the sleeve and a metal foil wrapped tightly around the sleeve over a length of 10 cm.

8.3.8 Insulations other than those mentioned in Sub-clauses 8.3.6 and 8.3.7 are considered to be satisfactory if they comply with the following:

Basic insulation and supplementary insulation shall each withstand the dielectric strength test specified in Sub-clause 9.2 unless the thickness of the insulation is at least 0.4 mm.

For double insulation either the basic insulation or the supplementary insulation shall have a thickness of at least 0.4 mm.

Reinforced insulation shall have a thickness of at least 2 mm. A thinner insulation is allowed, provided that it has a thickness of not less than 0.4 mm, and that it is not subjected to a mechanical stress which, at normal operating temperature, would be likely to lead to deformation or deterioration of the insulating material. In addition the insulating material shall withstand the dielectric strength test specified in Sub-clause 9.2.

These requirements do not apply to transformers complying with Sub-clause 13.8.

8.3.9 The construction of the apparatus shall be such as to prevent short-circuiting of insulations, between live parts and accessible metal parts or parts connected to them, due to accidental loosening of screws, etc.

The requirement is deemed to be met if the apparatus withstands the tests specified in Clause 11.

8.3.10 The construction of the apparatus shall be such that, should any wire become detached, the creepage distances and clearances are not reduced below the values specified in Sub-clause 8.3.4 by the natural movement of a detached wire.

This requirement does not apply if there is no risk of a wire becoming detached.

Compliance is checked by inspection and measurement.

Examples of methods deemed to prevent a wire end from becoming detached are:

a) the conductor of the wire is anchored to the tag before soldering, unless breakage close to the soldering place is likely to occur as a result of vibration;
b) wires are twisted together in a reliable manner;
c) wires are fastened together by insulating tape, sleeves or the like;
d) the conductor of the wire is inserted into a hole in the printed board before soldering, the hole having a diameter slightly greater than that of the conductor;
e) the conductor of the wire is securely wrapped around the terminal by means of a special tool;
f) the conductor of the wire is crimped to the terminal by means of a special tool.

The methods of Items *a)* to *f)* apply to internal wires and the methods of Items *a)* to *c)* to external flexible cords.

In case of doubt, the vibration test of Sub-clause 11.1.2 is carried out to verify compliance.

It is assumed that not more than one connection will become detached at the same time.

An accidental contact between detached ends of live wires and parts of the enclosure made of materials similar to those listed in Sub-clause 8.3.1 is allowed.

8.3.11 The construction of the apparatus shall be such that, if a test finger can partly enter the apparatus through a hole in the enclosure (see Figure 1, page 90), the tip of the test finger may be separated from any live parts by basic insulation only, provided contact cannot be made with the insulation material.

The basic insulation may be provided by a clearance having a value according to curve A of Table I.

Compliance is checked by measurement.

9. Insulation requirements

9.1 *Moisture treatment*

The safety of the apparatus shall not be impaired by humid conditions which may occur in normal use.

Compliance is checked by the humidity treatment described in this sub-clause, followed immediately by the tests of Sub-clause 9.2.

Electrical components, covers and other parts, which can be removed by hand, are removed and subjected, if necessary, to the humidity treatment with the main part.

Apparatus are subjected to the test prescribed in IEC Publication 68-2-3 (temperature: 40 ± 2 °C, relative humidity: 90% to 95%).

Before being placed in the chamber, the apparatus is brought to a temperature between 40 °C and 44 °C.

The apparatus is kept in the chamber for five days (120 h).

In most cases, the apparatus may be brought to the specified temperature by keeping it at this temperature for at least 4 h before the humidity treatment.

Some methods of achieving the specified relative humidities are described in IEC Publication 260: Test Enclosures of Non-Injection Type for Constant Relative Humidity.

The air in the chamber must be stirred and the chamber must be so designed that mist or condensed water will not precipitate onto the apparatus.

After this treatment, the apparatus shall show no damage in the sense of this standard.

9.2 *Insulation resistance and dielectric strength*

Insulation shall be adequate.

Compliance is checked by the following tests and, unless otherwise stated, immediately after the moisture treatment according to Sub-clause 9.1.

The insulations listed in Table III shall be tested:

- *for insulation resistance with 500 V d.c.;*
- *for dielectric strength as follows:*

Insulations stressed with d.c. (plus any ripple) voltage are tested with a d.c. voltage. Insulations stressed with a.c. voltage are tested with an a.c. voltage at mains frequency. Where corona, ionization, charge effects or the like may occur, a d.c. test voltage is recommended. The test voltages are applied for 1 min.

The measurement of the insulation resistance and the dielectric strength test are made in the humidity cabinet, or in the room in which the apparatus was brought to the prescribed temperature, after the reassembly of those parts which may have been removed.

The apparatus is deemed to comply with the requirement if the insulation resistance measured after 1 min is not less than the values given in Table III and no flashover or breakdown occurs during the dielectric strength test.

When testing enclosures of insulating material, foil is pressed tightly against accessible parts.

The test is not made on insulation the short-circuiting of which does not cause any shock hazard, e.g. in case one end of a secondary winding of a separating transformer is connected to an accessible metal part, the other end need not meet any special insulation requirement with regard to the same accessible metal part.

Resistors and capacitors complying with Sub-clauses 13.1 and 13.2 respectively, connected in parallel with the insulations to be tested, are disconnected. Inductors and windings, which otherwise would prevent the test from being made, are also disconnected.

In the case of apparatus with high-frequency pulse ignition, the ignition pulse is ignored in computing the test voltage if the duration of the pulse does not exceed 1 ms.

TABLE III

Insulation	*Insulation resistance*	*A.C. test voltage (peak) or d.c.*
1. *Between the poles of the circuit directly connected to the supply mains.*	2 MΩ	$2\hat{U} + 1410$ V
2. *Between parts separated by basic insulation or by supplementary insulation.*	2 MΩ	*Curve A (see Figure 9)*
3. *Between parts separated by reinforced insulation.*	4 MΩ	*Curve B (see Figure 9)*

The voltage $\hat{U}$ is the highest peak value occurring across the insulation under normal and fault conditions, the apparatus being connected to the rated supply voltage. The voltage across the basic insulation is to be determined with the supplementary insulation short-circuited and vice versa.

In respect of mains voltages in the range 220 V to 250 V (r.m.s.) the test voltages are 2 120 V peak for basic and supplementary insulations and 4 240 V peak for reinforced insulation.

Curves A and B of Figure 9, page 99, are defined by the following points:

Operating voltage (peak)	*Test voltage (peak)*	
	Curve A	*Curve B*
34 V	*707 V*	*1410 V*
354 V		*4 240 V*
1410 V	*3 980 V*	
10 kV	*15 kV*	*15 kV*
50 kV	*75 kV*	*75 kV*

Between conductors on a printed board, described in Sub-clause 4.3.1, the a.c. test voltage is $3\hat{U}$ with a minimum of 707 V peak.

Accessible metal parts may be connected together during the dielectric strength test.

An instrument to carry out the dielectric strength test is described in Figure 8, page 98

10. Fault conditions (see Sub-clause 4.3)

10.1 *Shock hazard*

Protection against electric shock shall still exist when the apparatus is operated under fault conditions.

Compliance is checked by making the tests described in Sub-clauses 8.1 and 8.2, modified as shown below, under fault conditions.

For terminal contacts, the permissible current is increased to 2.8 mA (peak).

The fault condition described in Sub-clause 4.3.9 shall be maintained until steady state has been reached, but not for more than 4 h.

If short-circuiting or disconnecting a resistor or a capacitor causes an infringement of the requirements, the apparatus is not deemed to be unsatisfactory, but the relevant part shall comply with the requirements of Clause 13.

If, during the tests, an insulation mentioned in Table III is subjected to a voltage exceeding the voltage occurring under normal operating conditions, and if this increase involves a higher test voltage according to Sub-clause 9.2, this insulation shall withstand a test for dielectric strength at the higher voltage, unless the higher voltage is due to the short-circuiting or disconnection of a resistor or a capacitor complying with the requirements of Clause 13.

It is advisable to identify beforehand all the component parts to be tested with a higher test voltage in order to avoid more than one moisture treatment.

10.2 *Heating*

When the apparatus is operated under fault conditions, no part shall reach such a temperature, nor shall flammable gases be liberated to such an extent, that there is a danger of fire to the surroundings of the apparatus. Any heat developed in the apparatus shall not impair its safety.

Compliance is checked by subjecting the apparatus to a heating test under fault conditions.

The temperature rises shall not exceed the values given in Table II, column II. However, higher temperature rises are allowed for windings and coil formers, provided that a failure of their insulation does not cause an infringement of the requirements regarding protection against electric shock, and that no flammable gases are liberated during the test.

It the temperature is limited by the operation of thermal releases, fuses or fusing resistors, the temperatures are measured 2 min after the operation of the device.

If no temperature-limiting device operates, the temperatures are measured after a steady state has been reached, but not later than after 4 h operation of the apparatus.

If the temperature is limited by fuses, the following additional test is carried out in case of doubt:

The fuse-link is short-circuited during the test and only the current through this short-circuit link, under the relevant fault conditions, is measured:

- *if this current remains less than 2.1 times the rated current of the fuse-link, the temperatures are measured after a steady state has been reached, but not later than after 4 h operation of the apparatus;*

- *if this current is either immediately 2.1 times the rated current of the fuse-link or more, or after a period of time reaches this value, both the fuse-link, and short-circuit link are removed at that moment and the temperatures are measured 2 min after the removal.*

In case of doubt the maximum resistance value of the fuse-link shall be taken into account when establishing the value of the current.

The above test is based on the fusing characteristics specified in IEC Publication 127: Cartridge Fuse-links for Miniature Fuses, which also gives the information necessary to calculate the maximum resistance value.

In determining the current through the fuse, consideration should be given to the fact that this current may vary as a function of time. It should be measured therefore as soon as possible after switching on, taking into consideration the heating time of the apparatus, especially where electronic tubes are used.

Temperatures are measured as indicated in Clause 6, except that, for parts so enclosed or located in the apparatus that internal flames cannot ignite materials outside the enclosure, the effect is checked by measuring the temperature of the enclosure of the part of the apparatus, whichever applies.

Melting of insulation materials not of importance within the meaning of this standard is disregarded.

To check whether gases liberated from component parts are flammable or not, a test with a high-frequency spark generator is made.

If a temperature rise exceeding the value given in Table II is due to short-circuiting an insulation, the apparatus is not deemed to be unsatisfactory but this insulation shall withstand a dielectric strength test as described in Sub-clause 9.2 preceded by the moisture treatment according to Sub-clause 9.1.

If a temperature rise exceeding the value given in Table II is due to short-circuiting or disconnecting a resistor, a capacitor or an inductor, the apparatus is not deemed to be unsatisfactory if the resistor, the capacitor or the inductor complies with the requirements of Clause 13 (see Sub-clause 4.3.6).

If a temperature rise exceeding the values of Table II is due to the disconnecting of a resistor, the overload test specified in Item b) of Sub-clause 13.1 is repeated on the resistor mounted in the apparatus, including the connections made by the manufacturer. During this test, the connections shall not fail.

If a temperature rise on a printed board at one or more small areas, the total area of which does not exceed 2 cm² for each fault condition, exceeds the values given in Table II, the apparatus is not considered to be unsatisfactory, provided no flammable gases are liberated during the test and, in addition, the printed board shall withstand the following flame test:

The test is made according to Sub-clause 4.3 of IEC Publication 249-1 modified and supplemented as follows:

- *the pre-conditioning in standard atmospheric conditions as prescribed in Sub-clause 1.1.1 is deleted;*
- *treatment of the specimens as prescribed in Sub-clause 4.3.3.3, first paragraph, is made at 125 ± 5 °C, during 24 h;*

The average burning time of the four specimens shall not exceed 15 s, irrespective of the thickness of the base material.

To verify compliance with the requirements of this sub-clause, it may be necessary to repeat the dielectric strength or insulation test.

11. Mechanical strength

11.1 *Complete apparatus*

The apparatus shall have adequate mechanical strength and be so constructed as to withstand such handling as may be expected in normal use.

Compliance is checked by the following tests. However, devices forming a part of the mains plug are only subjected to the impact test as described in Sub-clause 11.1.3.

11.1.1 *Bump test*

The apparatus is placed on a horizontal support of wood which is allowed to fall 50 times from a height of 5 cm onto a wooden table.

After the test, the apparatus shall show no damage in the sense of this standard.

11.1.2 *Vibration test*

The apparatus is subjected to a vibration endurance conditioning by sweeping, as specified in IEC Publication 68-2-6: Part 2: Tests — Test Fc and Guidance: Vibration (sinusoidal).

The apparatus is fastened in its normal position of use to the vibration-generator by means of straps round the enclosure. The direction of vibration is vertical and the severity is:

— *Duration:*	*30 min*
— *Amplitude:*	*0.35 mm*
— *Sweep frequency range:*	*10 Hz, 55 Hz, 10 Hz*
— *Sweep rate:*	*approximately one octave per minute*

After the test, the apparatus shall show no damage in the sense of this standard: in particular, no connection or part the loosening of which might impair safety shall have loosened.

11.1.3 *Impact test*

The apparatus is held firmly in the hand and is subjected to three blows from a spring-operated impact hammer as shown in Figure 4, page 94, applied to every point of the exterior that protects live parts and is likely to be weak, including handles, levers, switch knobs and the like, by pressing the hammer nose perpendicularly to the surface.

This test is also made on signal lamps and their covers, but only if they protrude from the enclosure by more than 5 mm or if the individual projected surface area exceeds 1 cm^2.

Flash tubes and incandescent lamps, other than signal lamps, are excluded from the impact test.

After the test, the apparatus shall withstand the dielectric strength test of Sub-clause 9.2 and shall show no damage in the sense of this standard; in particular, live parts shall not have become accessible, enclosures shall show no visible cracks and insulating barriers shall not have been damaged.

Damage to the finish, small dents which do not reduce creepage distances or clearances below the specified values, cracks which are not visible to the naked eye, and surface cracks in fibre-reinforced mouldings and the like are ignored.

12. Parts connected to the supply mains

12.1 Creepage distances and clearances between parts directly connected to the supply mains shall have at least the values given by curve A of Table I.

Compliance is checked by inspection.

12.2 The insulating materials referred to in Sub-clause 6.2 shall be resistant to fire.

A test is under consideration.

13. Components

Where components are part of a range of values it is usually not necessary to test every value within that range. If this range of values consists of several technologically homogeneous sub-ranges, the sample should be representative of each of these sub-ranges. Moreover, it is recommended, where possible, to make use of the concept of structurally similar components.

13.1 *Resistors*

Resistors the short-circuiting or disconnecting of which would cause an infringement of the requirements for operation under fault conditions (see Clause 10), shall have an adequate stable resistance value under overload.

Such resistors shall be positioned inside the enclosure of the apparatus.

Compliance is checked by the tests of Item a) or of Item b), carried out on a sample of ten specimens.

Before the tests of Item a) or Item b), the resistance of each specimen is measured and the sample is then subjected to the damp heat test prescribed in IEC Publication 68-2-3, severity 21 days.

a) For resistors connected between live parts and accessible metal parts, the ten specimens are each subjected to 50 discharges at a maximum rate of 12/min, from a 1 nF capacitor charged to 10 kV, in a test circuit as shown in Figure 3a, page 92.
After this test, the value of resistance shall not differ more than 50% from the value measured before the damp heat test.
No failures are allowed.

b) For other resistors, the ten specimens are each subjected to a voltage of such a value that the current through it is 1.5 times the value measured through a resistor, having a resistance equal to the specified nominal value, which is fitted to the apparatus, when operated under fault conditions. During the test the voltage is kept constant.
The value of resistance is measured when steady state is attained and shall not differ more than 30% from the value measured before the damp heat test.
No failures are allowed.

For resistors connected between live parts and accessible metal parts, the creepage distances and clearances between end-cap terminations shall comply with the requirements of Sub-clause 8.3.4.

Resistors with internal end-lead terminations are only allowed if the internal spacings are clearly and precisely defined.

Compliance is checked by measurement and inspection.

13.2 *Capacitors*

13.2.1 Capacitors and resistor-capacitor units, the short-circuiting or disconnecting of which would cause an infringement of the requirements under fault conditions with regard to shock hazard, shall have adequate dielectric strength.

Compliance is checked by the following tests.

13.2.2 General

For capacitors and units comprising capacitors with shunt resistors, a sample of 30 components is required. All 30 are subjected to the initial resistance measurement (Sub-clause 13.2.3). A sample of ten is then subjected to the surge test (Sub-clause 13.2.4), another sample of ten is subjected to the endurance test (Sub-clause 13.2.5), and the remaining ten are subjected to the humidity test (Sub-clause 13.2.6).

13.2.3 Initial resistance

13.2.3.1 *The resistance measured between the terminals of a component comprising a capacitor and a shunt resistor shall be not less than 0.5 MΩ, nor more than 4 MΩ.*

The insulation resistance of a capacitor (where there is no shunt resistor), measured at 500 V (d.c.) maintained for 2 min, shall be not less than 1 000 MΩ.

13.2.3.2 *The sample of 30 is to be measured, and the resistance of each component is to be within the specified limits.*

13.2.4 Surge test

13.2.4.1 *A component shall be subjected to 50 discharges at a maximum rate of 12/min, from a 1 nF capacitor charged to 10 kV.*

After the test:

- *a) the resistance between the terminals of a component comprising a capacitor and a shunt resistor shall not have changed by more than 50% of the value measured before the test;*
- *b) the insulation resistance of a capacitor (when there is no shunt resistor), measured at 500 V (d.c.), maintained for 2 min, shall be not less than 500 MΩ;*
- *c) the component shall withstand without breakdown, for a period of 1 min, a 2000 V (r.m.s.) alternating voltage of mains frequency, applied between the terminals of the component and, for an insulated component, between the terminals connected together and the case, or a metal foil wrapped closely around the body of the component, but maintaining a 3 mm distance between the foil and each component terminal. The test voltage is to be obtained in the manner specified in Sub-clause 13.2.4.4.*

13.2.4.2 *The circuit to be used in performing the surge test is shown in Figure 3a), page 92.*

13.2.4.3 *If the component under test contains a resistor which would dissipate more than 0.5 W during the tests of Item c) of Sub-clause 13.2.4.1, the component is to be cooled during the test by immersion in a bath of silicone oil or mineral oil.*

13.2.4.4 *The test voltage specified in Item c) of Sub-clause 13.2.4.1 shall be obtained from a suitable transformer, the output voltage of which can be adjusted. The voltage is to be increased gradually from zero, at a rate of 75 V/s until the required test value is reached, and is to be held at that value for 1 min.*

13.2.4.5 *A sample of ten components is subjected to the surge test with no failures permitted. If one component fails, an additional sample of ten components is tested, all of which shall then comply with the surge test. If more than one of the first sample fail or if one or more of the second sample fail, the components are deemed not to be satisfactory.*

13.2.5 Endurance test

13.2.5.1 *After 1 500 h of operation of a component under the conditions described in Sub-clause 13.2.5.2:*

a) the resistance between the terminals of a component comprising a capacitor and a shunt resistor shall not have changed more than 50% of the value measured before the test;

b) the insulation resistance of a capacitor (where there is no shunt resistor), measured at 500 V (d.c.) maintained for 2 min, shall be not less than 500 MΩ;

c) the component shall satisfy the test of Item c) of Sub-clause 13.2.4.1.

13.2.5.2 *The components are placed in a circulating air oven for a period of 1 500 h. The air in the oven is maintained at a temperature of 85 ±2 C and a relative humidity of 50% or less. Throughout the test, the components are subjected to a 500 V (r.m.s.) alternating voltage of mains frequency, except that once each hour the voltage is increased to 1 000 V (r.m.s.) for 0.1 s. A fuse or other device of suitable sensitivity is connected in the supply circuit to each component, to indicate a failure, either permanent or of short duration. After 1 500 h, the components are allowed to cool to room temperature before being tested as described in Sub-clause 13.2.5.1.*

13.2.5.3 *A sample of ten components is subjected to the endurance test with no failures permitted. If one component fails, an additional sample of ten components is tested, all of which shall then comply with the endurance test. If more than one of the first sample fail or if one or more of the second sample fail, the components are deemed not to be satisfactory.*

13.2.6 Humidity test

13.2.6.1 *A component shall be subjected to the test prescribed in IEC Publication 68-2-3, severity 21 days.*

13.2.6.2 *After recovery:*

a) the resistance between terminals of a component comprising a capacitor and a shunt resistor shall not have changed by more than 50% of the value measured before the test;

b) the insulation resistance of a capacitor (when there is no shunt resistor), measured at 500 V (d.c.), maintained for 2 min, shall be not less than 300 MΩ;

c) the component shall satisfy the test of Item c) of Sub-clause 13.2.4.1.

13.2.6.3 *A sample of ten components is subjected to the humidity test with no failures permitted. If one component fails, an additional sample of ten components is tested, all of which shall then comply with the humidity test. If more than one of the first sample fail or if one or more of the second sample fail, the components are deemed not to be satisfactory.*

13.3 *Fusing and interrupting devices*

13.3.1 Thermal releases shall have adequate rupturing capacity.

Compliance is checked by a test in which are established such conditions as are necessary to cause the release to operate. During the test, repeated ten times, no sustained arcing and no damage in the sense of this standard shall occur.

If by construction the release element is destroyed by operation, the test is made on ten individual elements.

13.3.2 Fuse-links used in order to prevent the apparatus from becoming unsafe within the sense of this standard shall comply with IEC Publication 127 unless they have a rated current outside the range specified in that standard.

The rated current and symbol relative to the pre-arcing time/current characteristic of the fuse-link shall be marked on its holder or close to it, in the order given in IEC Publication 127.

Fuse-holders so designed that fuse-links can be connected in parallel in the same circuit, shall not be used.

Compliance is checked by the tests of Sub-clause 10.2 and by inspection.

13.3.3 Fusing resistors shall have adequate rupturing capacity.

Compliance is checked during the tests under fault conditions (see Sub-clause 10.2).

13.3.4 If live parts are rendered accessible during replacement of fusing or interrupting devices, access to such parts shall not be possible by hand operation only.

Compliance is checked by inspection.

13.4 *Mains switches*

13.4.1 Mains switches, if any, shall disconnect all parts of the apparatus from all poles of the supply mains with the exception of the protective earth conductor.

However, fuses, interference suppression coils, capacitors and discharge resistors between mains poles need not be disconnected.

Disconnection from all poles is not necessary if the apparatus is so constructed that, with the switch in the off position, no capacitor, except those between the mains poles, can remain under mains voltage stress.

Compliance is checked by inspection.

13.4.2 Mains switches shall have adequate making and breaking capacity and shall be so constructed that the moving contacts can come to rest only in the "on" and in the "off" positions.

Compliance is checked by inspection and by one of the following endurance tests:

a) the switch, tested as part of the apparatus working under normal operating conditions, is subjected to:

- *5 000 cycles of operation when used on apparatus having a stored energy not exceeding 150 J, or*
- *10 000 cycles of operation when used on apparatus having a stored energy exceeding 150 J.*

Both tests are carried out at a rate of one cycle per minute, the duration of the "on-load" period being 50 s and the "off-load" period being 10 s. During the "off-load" period the flash capacitor is discharged with a time constant of 1 s.

b) the switch, tested as a general purpose component in a circuit as shown in Figure 10, page 100, is subjected to:

- *5 000 cycles of operation when used on apparatus having a stored energy up to 150 J and*
- *10 000 cycles of operation when used on apparatus having a stored energy in excess of 150 J.*

Both tests are carried out at a rate of seven cycles per minute, the duration of the "on-load" and "off-load" periods being equal for each cycle.

The actuating member of the switch is operated so as to simulate normal use.

After the test, the switch shall show no damage in the sense of this standard and shall still be capable of operating as originally intended. In particular, it shall show no deterioration of the enclosure and insulations, no loosening of electrical connections or mechanical fixings and no seepage of sealing compound. It shall then comply with the tests of Sub-clauses 13.4.2.1 and 13.4.2.2 in the order given.

The tests are made on three specimens.

If one of the specimens fails in either of the tests of Sub-clauses 13.4.2.1 or 13.4.2.2, the tests of these sub-clauses are repeated on three new specimens, no failure being allowed.

13.4.2.1 The switch shall be so constructed that the temperature rise under normal operating conditions is not excessive.

Compliance is checked by the following test:

Following the endurance conditioning according to Item a) of Sub-clause 13.4.2, the switch is loaded for 1 h with the rated mains current of the flash apparatus (see Sub-clause 13.4.4).

Following the endurance conditioning according to Item b) of Sub-clause 13.4.2, the switch is fitted with conductors having a nominal cross-sectional area of 0.75 mm^2 and is then loaded for 1 h with its rated current.

In both cases, the current is passed through the specimen by means of an auxiliary switch.

The temperature of the terminals is determined by means of melting particles or similar indicators, or by means of thermocouples which are so chosen and positioned that they have negligible effect on the temperature being determined.

The temperature rise shall not exceed 55 K during the 1 h period.

13.4.2.2 The switch shall have adequate dielectric strength.

Compliance is checked by the following tests:

— *the switch shall withstand, in the "on" position, a dielectric strength test as specified in Sub-clause 9.2, without being previously subjected to the moisture treatment, the test voltage being decreased by 500 V r.m.s. (700 V peak). The voltage is applied between live parts and those parts which become accessible when the switch is mounted in an apparatus, and, in addition, between the poles in the case of an all-pole mains switch;*

— *the switch shall withstand, in the "off" position, a dielectric strength test as specified in Sub-clause 9.2, without being previously subjected to the moisture treatment, the test voltage being 1 000 V r.m.s. (1 410 V peak) across each contact gap. During the test, any capacitor or resistor in parallel with the contact gaps is disconnected.*

13.4.3 Switches shall be identified unambiguously.

Where switches are submitted for testing for subsequent use as general purpose components applicable to this standard, they shall comply with the relevant test of Sub-clause 13.4.2 as well as the requirements of the clauses of this standard where applicable. The switches shall be marked with type reference, manufacturer's name or trade mark, rated voltage, rated current and either the rated peak surge current or the ratio between the rated peak surge current and the rated current.

Compliance is checked by inspection and by the relevant tests.

Examples of marking of general purpose switches:

$$\frac{2/8}{250} \sim \text{ or } \frac{2\ 4\text{x}}{250} \sim \text{ or}$$

2 A/8 A 250 V ~ or 2 A/4x 250 V ~

The preferred rated currents are 1 A, 2 A and 5 A.

The preferred values of the ratio between the rated peak surge current and the rated current are 2, 4, 8, 16, 32, and 64.

Where the ratio is quoted, this number is followed by the sign x.

The values for the rated voltage are 130 V and 250 V.

13.4.4 The characteristics of the switch, with reference to the marking, shall be appropriate for the function of the switch in the apparatus under normal operating conditions.

Compliance is checked by inspection and by measurement.

The rated mains current of a flash apparatus is determined by the following formula:

$$I_r = 1/3 \sqrt{\hat{I}_0^2 + \hat{I}_0\hat{I}_1 + \hat{I}_1^2}$$

where:

$\hat{I}_0$ = *maximum mains current (peak value) immediately after a flash has been made*

$\hat{I}_1$ = *mains current (peak value) at the end of the re-charge period of the flash capacitor. The end of the re-charge period is determined by the indicator or, if there is no indicator, by the measured voltage on the flash capacitor, which shall be 85% of the maximum peak voltage, the apparatus supplied at its rated mains voltage.*

The apparatus is operated under normal operating conditions except that the apparatus is connected to its rated supply voltage.

$\hat{I}_0$ *and* $\hat{I}_1$ *are measured when the apparatus is ready for flash operation and has been connected to the mains supply for at least 30 min.*

The peak surge current is the maximum peak value of the mains current when the flash apparatus is switched on, after the flash capacitor has been discharged completely. Current spikes up to 100 μs duration are disregarded.

The measured peak surge current and calculated rated mains current (I_r) *shall not exceed the marked current rating of the mains switch.*

13.5 *Safety switches*

Safety switches if any shall disconnect the apparatus from all poles of the mains and shall operate satisfactorily, even if the enclosure of the apparatus is opened slowly.

Compliance is checked by inspection and by manual test, without, however, trying to maintain an arc.

13.6 *Voltage-setting devices*

The apparatus shall be so constructed that changing the setting from one voltage to another or from one nature of supply to another is unlikely to occur accidentally.

Compliance is checked by inspection and by manual test.

Changing of the setting which necessitates consecutive movements by hand is deemed to comply with this requirement.

13.7 *Batteries*

If screws are used to fasten covers of battery compartments, these screws shall be captive.

The battery shall be so arranged that there is no risk of accumulation of flammable gases.

Apparatus containing batteries holding liquid shall be so designed that insulations cannot be impaired by leakage of the liquid.

Compliance is checked by inspection.

13.8 *Windings*

13.8.1 Inductors

Inductors, the short-circuiting or disconnecting of which would cause an infringement of the requirements for operation under fault conditions (see Clause 10), shall have adequate overload capacity.

Compliance is checked by the following test.

When the inductor has reached the temperature which occurs after use of the apparatus for 4 h under normal operating conditions, it is connected for 1 min to an a.c. voltage of twice the value and twice the frequency of the voltage applied under normal operating conditions.

During the test, no defect is permitted.

For inductors subjected to pulses, tests are under consideration.

13.8.2 *Insulation of windings*

Separating transformers, induction motors where the power is supplied to the stator only, relay coils and as far as applicable, autotransformers, are considered to provide reinforced insulation between live parts and accessible metal parts or parts connected to accessible metal parts, if they are so constructed that their use will not impair the protection against electric shock.

The requirement is met when these components satisfy either the constructional requirements and dielectric strength test of Item a) or the test and constructional requirements of Item b).

a) All creepage distances and clearances shall comply with the requirements of Sub-clause 8.3.5 for reinforced insulation.
The coil-formers providing reinforced insulation shall have a thickness of at least 0.4 mm.

For separating transformers.

- *Partition walls providing reinforced insulation shall have a thickness of at least 0.4 mm.*

- *When a single coil-former with separate partition walls is used, special measures shall be taken. An example is by using an insulating film covering the slit where the partition wall meets the coil-former, in order to prevent reliably any conductive connection between the primary and secondary windings, even when a wire breaks within the winding.*

- *When the windings are positioned concentrically, there shall be reinforced insulation between the primary and secondary windings. However, the reinforced insulation may consist of three separate layers, provided that each combination of two layers placed in contact between the two metal pins as shown in Figure 8, page 98, can withstand the dielectric strength test of Table III, Item 3, without being previously subjected to the humidity treatment. Special mesures shall be taken to prevent a wire or a broken end of a wire slipping off the outer windings onto the inner windings, or vice versa.*

- *The insulation between the primary and secondary windings and between the primary windings and the iron core, if the iron core is connected to accessible metal parts, and between secondary windings and the iron core, if the iron core is connected to live parts, shall withstand the dielectric strength test of Table III, Item 3, immediately after having been subjected to the humidity treatment specified in Sub-clause 9.1.*

For other components:

- *The insulation between the live windings and accessible metal parts, or parts intended to be connected to accessible metal parts, shall withstand the dielectric strength test of Table III, Item 3, immediately after having been subjected to the humidity treatment specified in Sub-clause 9.1.*

b) Three specimens of the component are subjected to seven cycles, each consisting of the following sequence of tests, with a recovery period of 24 h in ambient conditions between each cycle.
The specimens are placed in an oven for a period of 72 h at a temperature equal to the value of the temperature rise as determined by the test of Sub-clause 6.1 plus 70 °C. For separating transformers a voltage of 500 V r.m.s. is applied between the primary and secondary windings.

After 24 h recovery at ambient conditions, the specimens are subjected to the test prescribed in IEC Publication 68-2-6, with the following parameters:

Duration: 3 min
Amplitude: 1.2 mm
Frequency: 55 ± 5 Hz
Direction: vertical

During the vibration test, the specimens are positioned and fixed as in the apparatus.

After the vibration test, the specimens are subjected to the humidity treatment specified in Sub-clause 9.1 for a duration of 48 h.

For separating transformers after each humidity exposure, the insulation between the primary and secondary windings and between the primary windings and the iron core, if the iron core is connected to accessible metal parts, and between secondary windings and the iron core, if the iron core is connected to live parts, shall withstand the dielectric strength test of Table III, Item 2.

For other components, after each humidity exposure, the insulation between the live windings and accessible metal parts, or parts intended to be connected to accessible metal parts, shall withstand the dielectric strength test of Table III, Item 2.

The specimen is deemed to be satisfactory if no flashover or breakdown occurs during the dielectric strength test at the end of each cycle.

Separating transformers shall moreover comply with one of the following requirements:

- *the coil-former and the partition wall between the relevant windings shall consist of one piece part (e.g. one moulded part), or*
- *when a single coil-former with separate partition walls is used, special measures shall be taken. An example is by using an insulating film covering the slit where the partition wall meets the coil-former, in order to prevent reliably any conductive connection between the primary and secondary windings, even when a wire breaks within the winding, or*
- *when the windings are positioned concentrically on a single coil-former, they shall be separated by a barrier and special measures shall be taken to prevent a wire or a broken end of a wire slipping off the outer windings onto the inner windings, or vice versa.*

A component complying with these requirements is not inspected as regards the internal creepage distances, internal clearances and distances through insulations.

13.8.3 *Transformers intended to provide protection by earthing*

Transformers intended to provide protection by earthing (see Sub-clause 8.3.3) shall comply with the following requirement.

A metal screen intended to be connected to the safety earth terminal of an apparatus shall be positioned between the primary and secondary windings in such a way that it effectively prevents the primary voltage being applied to the secondary winding in the case of an insulation fault.

13.9 *Motors*

13.9.1 Motors shall be so constructed as to prevent, in extended normal use, any electrical or mechanical failure impairing compliance with this standard. The insulation shall not be affected and contacts and connections shall be such that they do not work loose by heating, vibration, etc.

Compliance is checked by the following tests carried out on the apparatus under normal operating conditions.

a) The motor is connected to 1.1 times the rated supply voltage and to 0.9 times the rated supply voltage, each time for 48 h. Motors for short-time or intermittent operation are connected for periods in accordance with the operating time if limited by the construction of the apparatus.

In the case of short-time operation, suitable cooling intervals are inserted.

It may be convenient to carry out this test immediately after the test of Sub-clause 6.1.

b) The motor is started 50 times while connected to 1.1 times the rated supply voltage and 50 times while connected to 0.9 times the rated supply voltage, each period of connection being at least 10 times the period from start to full speed, but not less than 10 s.

The intervals between starts shall be not less than three times the period of connection.

c) In addition, a motor provided with a centrifugal or other automatically operated starting switch, is started 5 000 times at 0.9 times the rated supply voltage. During the test, additional ventilation may be used.
If the apparatus provides for more than one speed, the test is carried out at the most unfavourable speed.

After these tests, the motor shall withstand the dielectric strength test of Sub-clause 9.2, no connection shall have loosened and there shall be no deterioration impairing the safety.

For induction motors with power supplied to the stator only, see also Sub-clause 13.8.2.

13.9.2 Motors with rotating windings placed in grooves and subjected to a voltage over 34 V (peak) shall have creepage distances and clearances of at least:

— 2 mm for insulation between iron cores and windings of enamelled wires;
— 4 mm for insulation between iron cores and accessible parts.

Compliance is checked by measurement.

13.9.3 Motors shall be so constructed or mounted that wiring, windings, commutators, slip-rings, insulations, etc., are not exposed to oil, grease or other substances having a deleterious effect.

Compliance is checked by inspection.

13.9.4 Screw-type brush caps shall be capable of being screwed home to a shoulder or similar abutment and shall engage by a minimum of three full threads.

Compliance is checked by inspection and by manual test.

13.9.5 Moving parts liable to cause personal injury shall be so arranged or enclosed as to provide in normal use adequate protection against this danger. Protective enclosures, guards and the like shall have adequate mechanical strength. They shall not be removable by hand.

Compliance is checked by inspection and by manual test.

13.9.6 Series motors shall have adequate mechanical strength.

Compliance is checked by inspection and by connection to 1.3 times the rated supply voltage for 1 min with the lowest possible load.

After the test, windings or connections shall not have loosened and there shall be no other deterioration impairing the safety of the motor.

14. Terminal devices

14.1 *Plugs and sockets*

14.1.1 Plugs and appliance couplers for the connection of the apparatus to the supply mains and socket-outlets for providing mains power to other apparatus shall comply with the relevant specifications for plugs and socket-outlets and for appliance couplers.

Plugs and appliance couplers which are live, although not intended for the connection of the apparatus to the supply mains, shall comply with IEC Publication 83: Plugs and Socket-outlets for Domestic and Similar General Use. Standards, and IEC Publication 320: Appliance Couplers for Household and Similar General Purposes, respectively, as far as applicable, with the exception of the shape and dimensions.

They shall not be compatible with mains plugs, mains socket-outlets and appliance couplers.

Mains socket-outlets mounted on Class II apparatus shall only allow connection to these outlets of other Class II apparatus.

Mains socket-outlets mounted on Class I apparatus shall either allow connection of Class II apparatus only or shall be provided with protective earth contacts which are reliably connected to protective earth terminals or contacts.

Compliance is checked according to the relevant specification and by inspection.

14.1.2 Connectors not intended for the mains supply shall not be interchangeable with the mains plugs, socket-outlets or appliance couplers, complying with the relevant specifications.

Compliance is checked according to the relevant specification and by inspection.

14.2 *Devices forming a part of the mains plug*

14.2.1 A device provided with pins intended to be introduced into fixed socket-outlets shall not impose undue strain on these socket-outlets.

Compliance is checked by engaging the device, as in normal use, with the socket-outlet of a test apparatus as shown in Figure 6, page 96. The balancing arm of the test apparatus pivots about a horizontal axis through the centre lines of the contact tubes of the socket-outlet at a distance of 8 mm behind the engagement face of the socket-outlet.

With the device not in engagement, the balancing arm is in equilibrium, the engagement face of the socket-outlet being in the vertical position.

After the device has been engaged, the torque to be applied to the socket-outlet to maintain its engagement face in the vertical plane is determined by the position of a weight on the balancing arm. The torque shall not exceed 0.25 Nm.

This test is compatible with the test described in the IEC standard for plugs and socket-outlets for household and similar purposes — Part 1 (in preparation).

The testing device shown in Figure 6, page 96, is intended for the testing of devices forming a part of the mains plug with dimensions in accordance with plugs of Group C in IEC Publication 83.

For devices forming a part of the mains plug with dimensions of Group A or Group B in IEC Publication 83, other test devices and requirements may be necessary.

14.2.2 The device shall comply with the standards for the dimensions of mains plugs.

Compliance is checked by measurement in accordance with the relevant standard.

The dimensions of some types of mains plugs are specified in IEC Publication 83.

14.3 *Terminals for external flexible cords*

14.3.1 Terminals shall be so located or shielded that even if a strand of a conductor should escape from a terminal, there is no risk of accidental contact between live parts and accessible metal parts.

A free strand of a live conductor shall not touch any accessible metal part and a strand of an earthing conductor, if any, shall not touch any live part.

Compliance is checked by inspection and by the following test.

An 8 mm length of insulation is removed from the end of a stranded conductor having the nominal cross-sectional area specified in Clause 15, which is then connected to the terminal with one strand free.

The free strand is bent in every possible direction without tearing back the insulation and without bending the strand around barriers and it shall not make contact prohibited by the requirement.

14.3.2 Screw terminals shall be so fixed that they will not work loose when the screws are tightened or loosened.

Compliance is checked by connecting and disconnecting ten times a conductor of the specified maximum cross-sectional area.

The value of the torque to be applied shall be 2/3 of the value given in Table V.

Screw terminals may be prevented from working loose by two fixing screws, by fixing with one screw in a recess without appreciable play, or by other suitable means.

14.3.3 Screw terminals shall allow connection to be made with sufficient contact pressure without damaging the conductors. Furthermore, they shall allow a conductor to be connected without special preparations (e.g. soldering of the end of the conductor, use of cable lugs or bending of eyelets) and they shall prevent the bare conductors from slipping out when the screws are tightened.

Compliance is checked by inspection of the conductor after it has been fitted according to Sub-clause 14.3.2 for the first time.

14.3.4 The supply conductors and the earthing conductor of a non-detachable mains cord or cable shall not be soldered directly to the conductors of a printed board.

Compliance is checked by inspection.

14.4 Protective earth terminal

If an apparatus is provided with a protective earth terminal, the following shall apply:

a) for apparatus provided with a connector socket for the mains supply, the protective earth contact shall be an integral part of this socket;

b) for apparatus to be connected to fixed wiring or provided with a non-detachable flexible cord or cable, the protective earth terminal shall be adjacent to the mains terminals.

The protective earth conductor shall be connected to a screw terminal, to a soldered termination or to another device of comparable effectiveness.

The protective earth terminal shall be of a robustness at least equal to that of the mains terminals and of a type such that the same tools can be used for the connection of the conductors.

All parts of a protective earth terminal shall be such that there is no danger of corrosion resulting from contact with the copper of the earth conductor or with any other metal part.

A protective earth terminal shall comply with the requirements of Sub-clause 14.3. In addition, either the screw or the body shall be of brass or of other metal no less resistant to corrosion and the contact surfaces shall be bare metal. It shall not be possible to loosen the screw by hand.

Compliance is checked by inspection and by manual test.

Requirements and tests for connecting means other than screw terminals and soldered terminations are under consideration.

The connection between the protective earth terminals and parts required (see Sub-clause 8.3.3) to be connected thereto shall be of a low resistance.

Compliance is checked by the following test.

A current of 10 A derived from an a.c. source with a no-load voltage not exceeding 6 V is passed for 1 min between the protective earth terminal and each of the accessible metal parts in turn.

The voltage drop between the protective earth terminal of the apparatus and the accessible metal part is measured and the resistance is calculated from the current and this voltage drop.

The resistance of the flexible cord is not included in the resistance measurement.

The resistance shall not exceed 0.5 Ω.

Care is taken that the contact resistance between the tip of the measuring probe and the metal part under test does not influence the test results.

In the case of a low rated supply voltage, a reduced resistance value may be necessary.

15. External flexible cords

15.1 Mains supply flexible cords shall comply with IEC Publication 227: Polyvinyl Chloride Insulated Cables of Rated Voltages up to and including 450/750 V, or IEC Publication 245: Rubber Insulated Cables of Rated Voltages up to and including 450/750 V.

A non-detachable mains cord shall be of the same type as prescribed for cords sets in IEC Publication 799: Cord Sets.

Compliance is checked by testing mains supply flexible cords according to IEC Publications 227 or 245 and by inspection.

In some countries, non-sheathed flexible cords are allowed.

Non-detachable flexible cables and cords of Class I apparatus shall be provided with a green/yellow core, connected to the protective earth terminal of the apparatus and if a plug is provided, to the protective earth contact of the plug.

Compliance is checked by inspection.

The colour code for cores of flexible mains cords is contained in IEC Publication 173: Colours of the Cores of Flexible Cables and Cords.

15.2 Conductors of mains supply cords shall have such a cross-sectional area that when a short-circuit occurs at the apparatus end of the cord, the protective devices in the electrical installation operate before the cord overheats.

Compliance is checked by inspection.

A consequence of this requirement is that the minimum required cross-sectional area for such conductors depends on the local wiring rules.

A nominal cross-sectional area of 0.75 mm^2 will satisfy all national standards with the exception of those valid in the United States of America and Canada, where a nominal cross-sectional area of 0.81 mm^2 is required.

A nominal cross-sectional area of 0.5 mm^2 is allowed provided the cord is non-detachable, the maximum current consumption does not exceed 2 A and the flexible cord is not longer than 2 m.

15.3 Conductors of flexible cords used as connection between the apparatus and other apparatus used in combination with it, shall have a cross-sectional area such that the temperature rise of the insulation under normal operating conditions and under fault conditions shall not be excessive.

Compliance is checked by inspection. In case of doubt, the temperature rises of the insulation are determined under normal operating conditions and under fault conditions; the temperature rises shall not exceed the values given in the appropriate columns of Table II.

15.4 *a)* Flexible cords used as connection between the apparatus and other apparatus used in combination with it, and comprising live conductors, shall have adequate dielectric strength.

Compliance is checked by the following test:

A specimen of the cord, 5 m long, is immersed for 24 h in water at a temperature of 20 ± 5 °C, a length of about 10 cm at each end of the specimen being kept above the water. A test voltage of 4 $\hat{U}$ or 2 820 V (peak), whichever is the higher, is then applied for 15 min between each live conductor and the water.

In addition, this voltage is applied between each live conductor and each conductor intended to be connected to accessible metal parts of the apparatus.

No breakdown shall occur during the tests. The voltage U is the higher value occurring across the insulation either under normal operating conditions or under fault conditions.

If a length of 5 m of cord cannot be obtained, the longest available piece is used.

b) Flexible cords used as connection between the apparatus and other apparatus used in combination with it, and comprising five conductors, shall withstand flexing and other mechanical stresses occurring in normal use.

Compliance is checked by the flexing test given in Sub-clause 5.6.3.1 of IEC Publication 227-1: Part 1: General Requirements, and in Sub-clause 3.1 of IEC Publication 227-2: Part 2: Test Methods, except that the following table applies:

TABLE IV

Overall diameter (D) of the flexible cable or cord (mm)	Mass (kg)	Pulley diameter (mm)
$D \leqslant 6$	1.0	60
$6 < D \leqslant 12$	1.5	120
$12 < D \leqslant 20$	2.0	180

The carrier moves to and fro 15 000 times (30 000 movements).

The voltage between the conductors is U, as defined in Item a) of Sub-clause 15.4.

After the test, the specimen shall withstand the dielectric strength test specified in Item a) of Sub-clause 15.4.

'5.5 The apparatus shall allow the external flexible cords, comprising one or more live conductors, to be so connected that the connecting points of the conductors are relieved from strain, that the outer covering is protected from abrasion, and the conductors are prevented from twisting.

Moreover, it shall not be possible to push an external cord back into the apparatus through its aperture if this involves danger.

The method by which the relief from strain and the prevention of twisting is provided shall be clearly seen.

Makeshift methods, such as tying the cord into a knot or tying the cord with a string, are not permitted

The devices for strain and twist relief shall either be made of insulating material, or have a fixed covering of insulating material other than natural rubber, if an insulation fault of the cord or the conductor may make accessible metal parts live.

For Class I apparatus, the arrangement of the terminals for the mains supply flexible cord, or the length of the conductors between the device for strain and twist relief and the terminals, shall be such that the live conductors become taut before the conductor connected to the protective earth terminal, if the cord slips out of the device for strain and twist relief.

Compliance is checked by inspection and by the following test.

The apparatus is fitted with the flexible cord, the devices for strain and twist relief being appropriately used. The conductors are introduced into the terminals, and the terminal screws, if any, are slightly tightened, so that the conductors cannot easily change their position.

After this preparation, pushing the cord further into the apparatus shall not be possible or shall cause no danger.

A mark is made on the cord, under strain, near the aperture, and the flexible cord is subjected 100 times to a pull of 40 N (4 kgf) for a duration of 1 s each. The pull shall not be applied in jerks.

Immediately afterwards, the cord is subjected for a period of 1 min to a torque of 0.25 Nm (2.5 kgf·cm).

During the test, the cord shall not be displaced by more than 2 mm, the measurement being made while the cord is still under strain; the ends of the conductors shall not be noticeably displaced in the terminals and no damage to the flexible cord shall be caused by the devices for strain and twist relief.

The test is made with the type of flexible cord attached to the apparatus.

15.6 Inlet openings for flexible cables or cords shall be in insulating material or be provided with bushings of insulating material, which is substantially free from ageing effects under conditions of normal use. The openings shall be so shaped that there is no risk of damage to the cable or cord during its introduction and subsequent movements.

Compliance is checked by inspection, by fitting flexible cords and by the following test.

Bushings of insulating material are subjected to an ageing test for 10 days (240 h) at a temperature 30 °C above the temperature to which they are subjected under normal operating conditions, with a minimum of 70 °C.

After the test, the bushing is subjected to the dielectric strength test of Sub-clause 9.2, the test voltage being applied between a metal rod of the same section as the cord, inserted instead of the cord, and the metal part in which the bushing is fixed.

16. Electrical connections and mechanical fixings

16.1 Screw terminals providing electrical contact and screw fixings which during the life of the apparatus will be loosened and tightened several times shall have adequate strength.

Screws exerting contact pressure and screws with a diameter less than 3 mm which form part of the above-mentioned screw fixings shall screw into a metal nut or a metal insert.

However, screws with a minimum diameter of 1.8 mm are allowed, without a metal nut or a metal insert, provided:

- they are not used for electrical connections;
- they are not intended to be operated by the user;
- the fixing of a single part is made by more than two screws.

Screw fixings which during the life of the apparatus will be loosened and tightened several times include terminal screws, screws for fixing covers (as far as they must be loosened to open the apparatus), screws for fixing handles, knobs and the like.

Compliance is checked by the following test.

The screws are loosened and then tightened, with a torque according to Table V;

- *five times in the case of screws operating in a thread in metal,*
- *ten times in the case of screws operating in wood or in a thread in insulating material.*

In the latter case, the screws are to be completely removed and reinserted each time.

The screws shall not be tightened in jerks.

After the test, there shall be no deterioration impairing the safety of the apparatus.

The material in which the screws are inserted is verified by inspection.

TABLE V

Nominal diameter of screw *(mm)*	*Torque (Nm (kgf · cm))*	
	Screws with heads	*Screws without heads*
1.8	*0.2 (2)*	*0.10 (1.0)*
2.2	*0.3 (3)*	*0.15 (1.5)*
2.5	*0.4 (4)*	*0.20 (2.0)*
3	*0.5 (5)*	*0.25 (2.5)*
3.5	*0.8 (8)*	*0.4 (4)*
4	*1.2 (12)*	*0.7 (7)*
5	*2.0 (20)*	*0.8 (8)*
6	*2.5 (25)*	— —

16.2 Means shall be provided to ensure the correct introduction of screws into female threads in non-metallic material, if they will be loosened and tightened several times during the life of the apparatus and contribute to safety.

Compliance is checked by inspection and by manual test.

This requirement is deemed to be met if introduction in a slanting manner is prevented, e.g. by guiding the screw in the part to be fixed, by a recess in the nut or a lead to the screw.

16.3 Screws or other fixing devices intended to fix covers or the like, shall be captive in order to prevent replacement during servicing by screws or other fixing devices, which might cause a reduction of creepage distances or clearances between accessible metal parts and live parts, below the values given in Table I.

Such screws need not be captive if, when replaced by screws having a length of ten times their nominal diameter, the distances are not less than those stated in Table I.

Compliance is checked by inspection and measurement.

16.4 Electrical connections in parts directly connected to the supply mains (see Sub-clause 2.9) shall be so designed that contact pressure is not transmitted through insulating material other than ceramic, unless there is sufficient resiliency in the metallic parts to compensate for any possible shrinkage of the insulating material.

Compliance is checked by inspection.

16.5 A screw or rivet which fixes together parts directly connected to the mains, carrying a current of more than 20 mA, and which serves also as a mechanical fixing, shall be locked against loosening.

Compliance is checked by inspection and by manual test.

Sealing by compound or the like provides satisfactory locking only for screw connections not subject to torsion.

For rivets, a non-circular shank or an appropriate notch may be a sufficient guard against rotation.

16.6 Cover-fixing devices, other than screws, shall have adequate mechanical strength, if the safety of the apparatus might otherwise be impaired.

The locked and unlocked positions of these devices shall be unambiguous, and it shall not be possible to unlock them inadvertently.

Compliance is checked by inspection, by operating the device and by the following test, usually applicable to those devices whose operation is effected by a combination of rotary and linear movements.

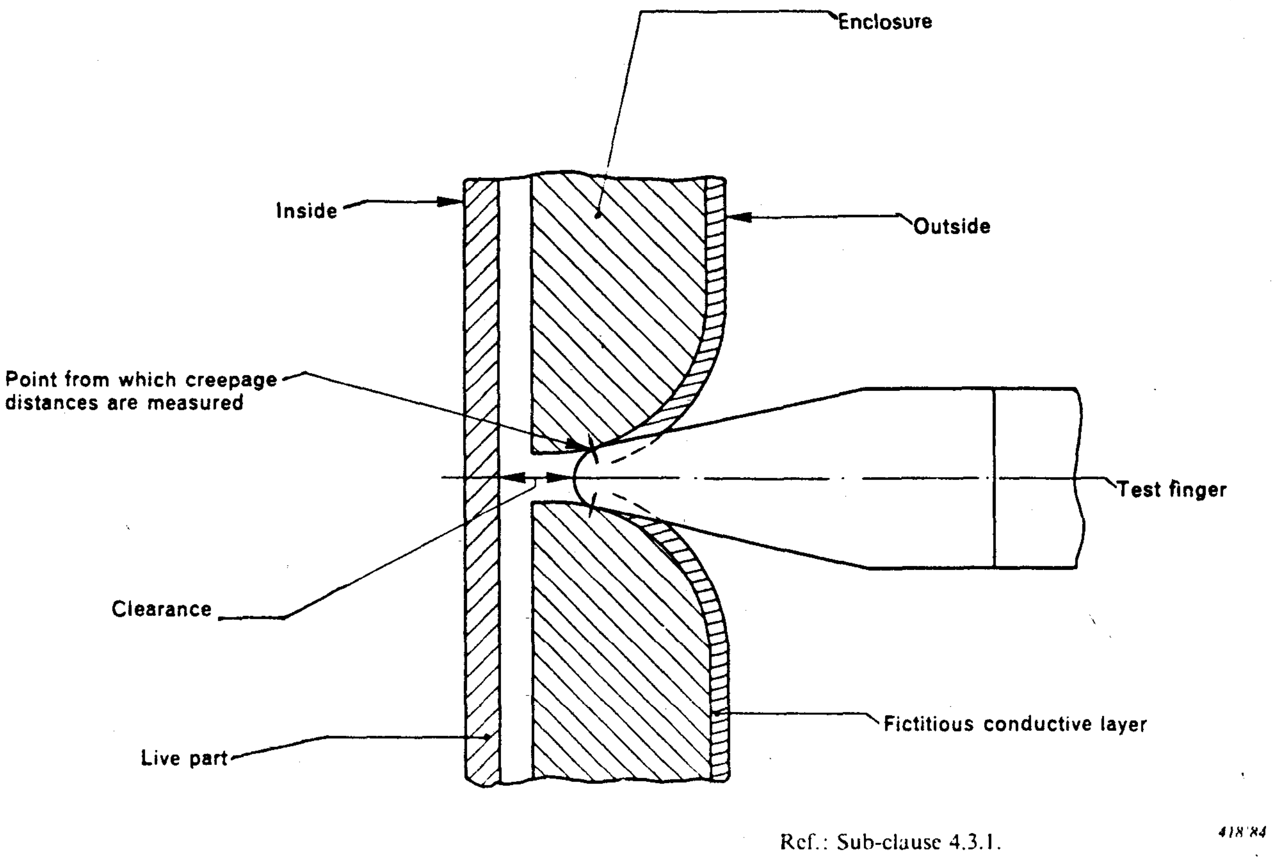
The device is locked and unlocked and the torques or forces necessary are measured. With the device in the locked position, a torque or force of twice the value necessary to lock the device, with a minimum of 1 Nm (10 kgf · cm) or 10 N (1 kgf) is applied in the locking direction, unless it is unlocked by a smaller torque or force in the same direction.

This operation is performed ten times.

The torque or force necessary for unlocking the device shall be at least 0.1 Nm (1 kgf · cm) or 1 N (0.1 kgf).

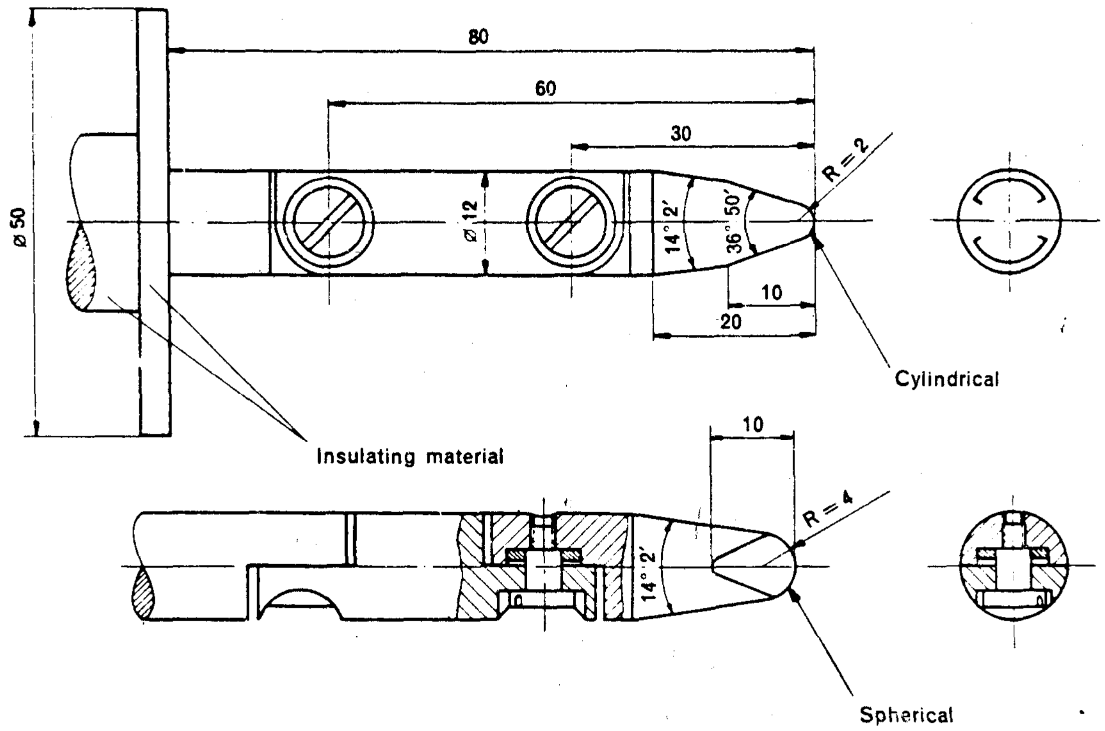
After the test, the device shall show no deterioration impairing the safety of the apparatus.

For certain types of locking devices, different tests may be necessary.


Enclosure
Inside
Outside
Point from which creepage distances are measured
Test finger
Clearance
Live part
Fictitious conductive layer
418/84

Ref.: Sub-clause 4.3.1.

FIG. 1 Accessible parts.



Dimensions in millimetres

Tolerances:

on angles: ±5'

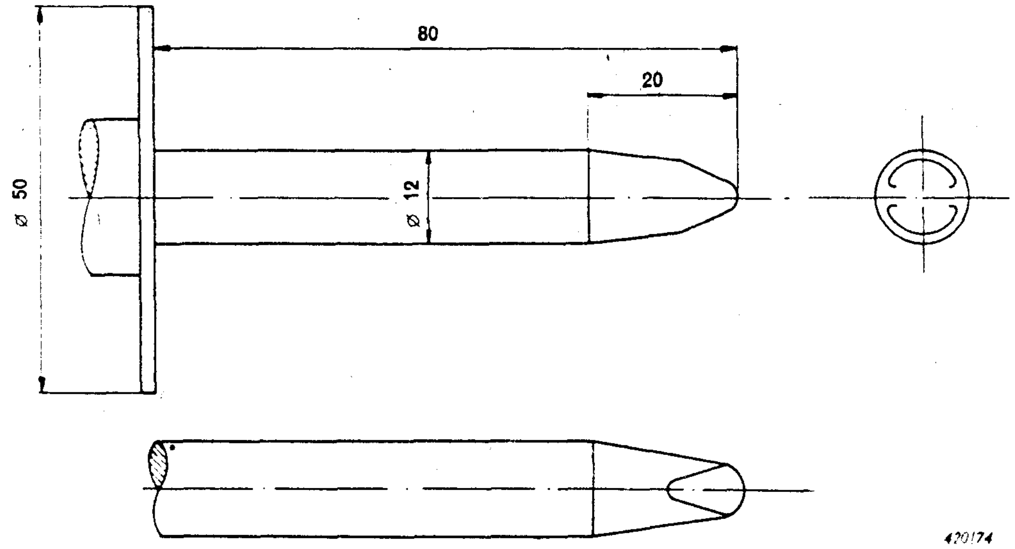
on linear dimensions

less than 25 mm: $^{+0.0}_{-0.05}$

over 25 mm: ±0.2

Ref.: Sub-clause 8.1.1.

FIG. 2*a)* Jointed test finger.

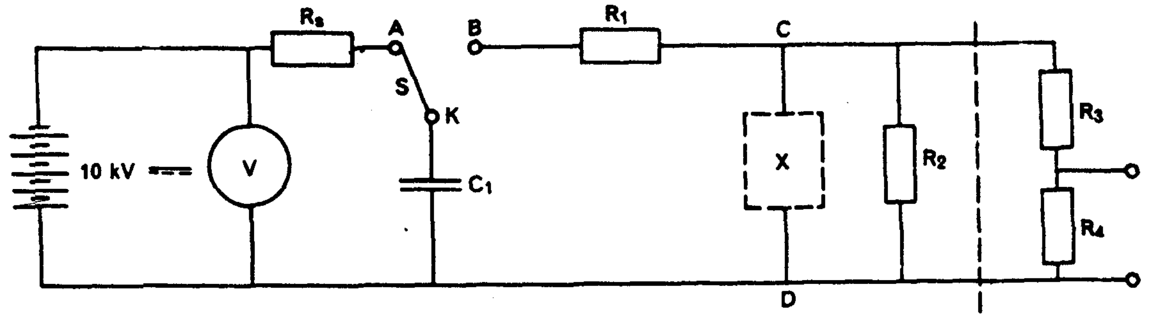


Dimensions of the fingertip: see Figure 2*a)*.

Dimensions in millimetres

Ref.: Sub-clause 8.1.1.

FIG. 2*b)* Rigid test finger.



$C_1 = 1$ nF
$R_1 = 1$ kΩ
$R_2 = 4$ MΩ
$R_3 = 100$ MΩ
$R_4 = 0{,}1$ MΩ
$R_5 = 15$ MΩ

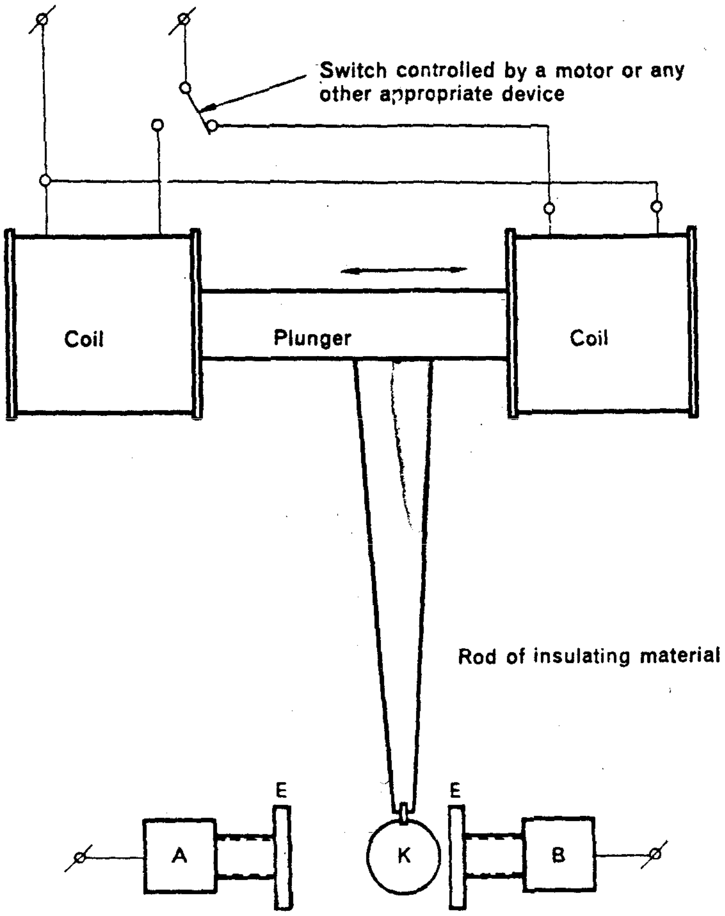
(R_2 is used only when the tests of Sub-clause 13.2 are performed on a component comprising a capacitor only.)

The switch S is a critical part of the circuit. It shall be so designed that as little as possible of the available energy is dissipated in arcing or inadequate insulation. An example of such a switch is given in Figure 3*b)*.

The component X under test is connected to the terminals C and D. Optionally the voltage divider R_3, R_4 may be provided so that an oscilloscope connected across R_4 permits the observation of the voltage waveform across the component under test. This voltage divider is compensated so that the observed waveform corresponds with that across the component under test.

References: Sub-clauses 13.1 and 13.2.

FIG. 3*a)* Circuit for surge tests.


Switch controlled by a motor or any other appropriate device
Coil
Plunger
Coil
Rod of insulating material
E
E
A
K
B

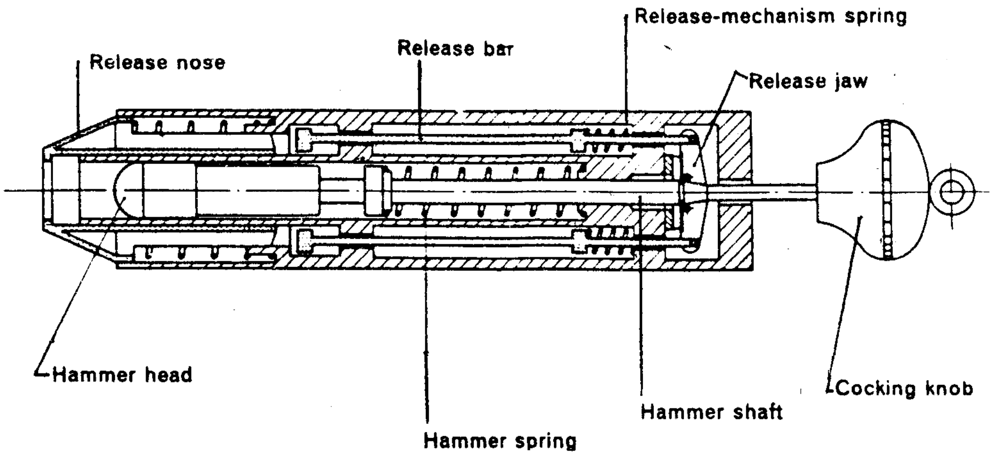
The switch (S in Figure 3*a)*) comprises the following parts:

The brass pillars A and B support circular electrodes E spaced at a distance of 15 mm; K is a brass sphere of 7 mm diameter and is supported on a rigid rod of insulating material approximately 150 mm long.

A. B and K are connected as shown in Figure 3*a)*, K by means of a flexible wire.

Care must be taken to avoid bouncing of sphere K.

FIG. 3*b)* Example of a switch to be used in the circuit for surge tests.



The apparatus consists of three main parts: the body, the striking element and the spring-loaded release nose.

The body comprises the housing, the striking element guide, the release mechanism and all parts rigidly fixed thereto. The mass of this assembly is 1 250 g.

The striking element comprises the hammer head, the hammer shaft and the cocking knob. The mass of this assembly is 250 g.

The hammer head has a hemispherical face of radius 10 mm and is of polyamide having a Rockwell hardness of R 100; it is fixed to the hammer shaft in such a way that the distance from its tip to the plane of the front of the nose, when the striking element is on the point of release, is 20 mm.

The nose has a mass of 60 g and the nose spring is such that it exerts a force of 20 N when the release jaws are on the point of releasing the striking element.

The hammer spring is adjusted so that the product of the compression, in millimetres, and the force exerted, in newtons, equals 1 000, the compression being approximately 20 mm. With this adjustment, the impact energy is 0.5 ± 0.05 Nm.

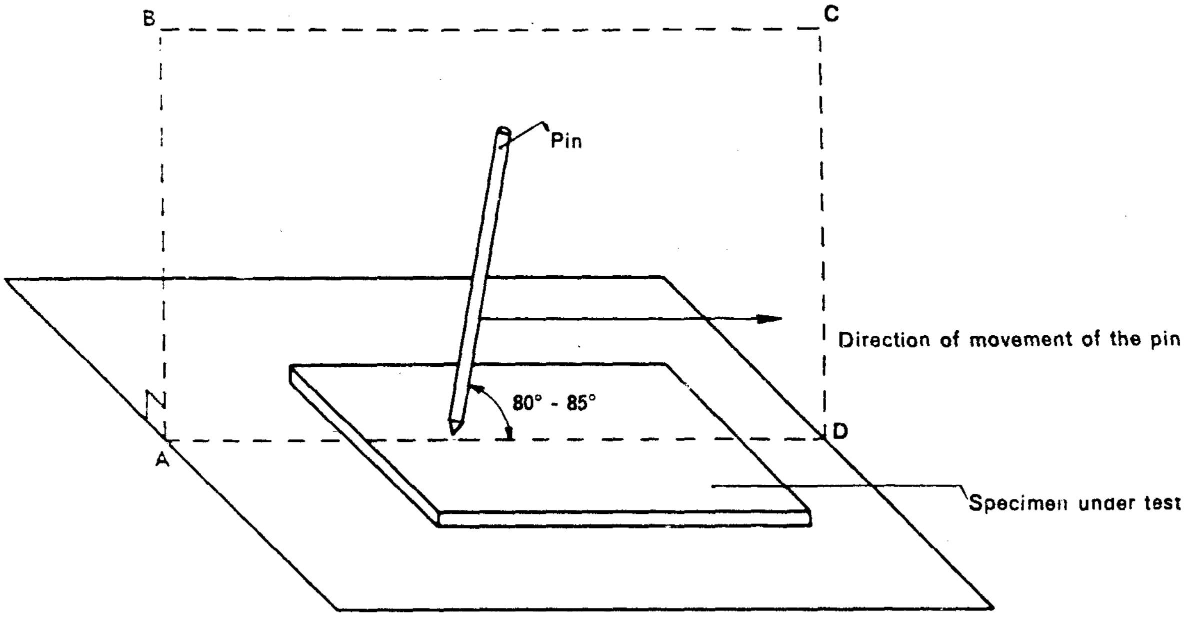
The release mechanism springs are adjusted so that they exert just sufficient pressure to keep the release jaws in the closed position.

The apparatus is cocked by pulling the cocking knob back until the release jaws engage with the groove in the hammer shaft.

The blows are applied by pushing the release nose against the sample in a direction perpendicular to the surface at the point to be tested. The pressure is slowly increased so that the nose moves back until it is in contact with the release bars, which then move to operate the release mechanism and allow the hammer to strike.

Ref.: Sub-clauses 8.3.6 and 11.1.3.

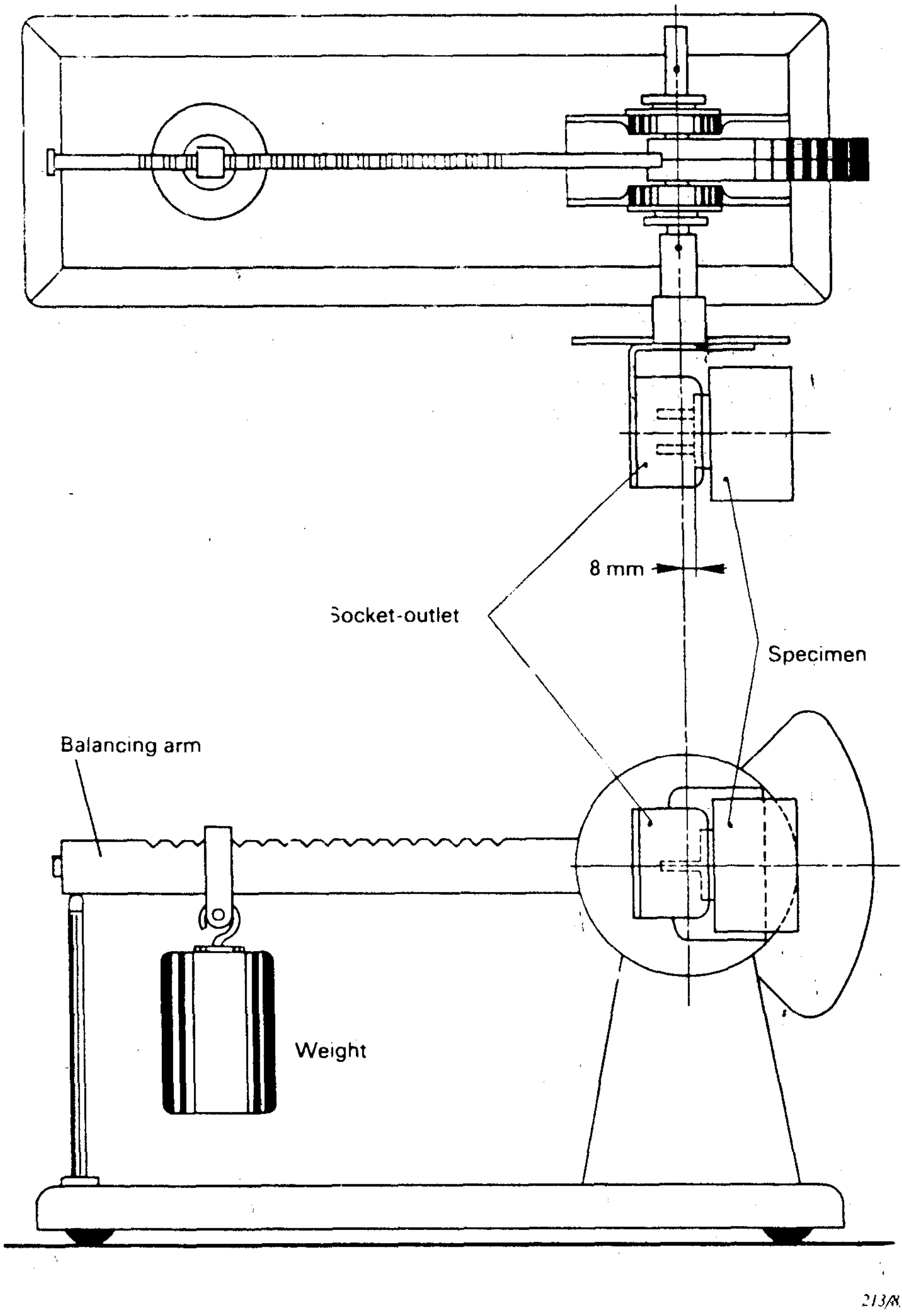
FIG. 4. Test hammer.



The pin is in the plane A B C D which is perpendicular to the specimen under test.

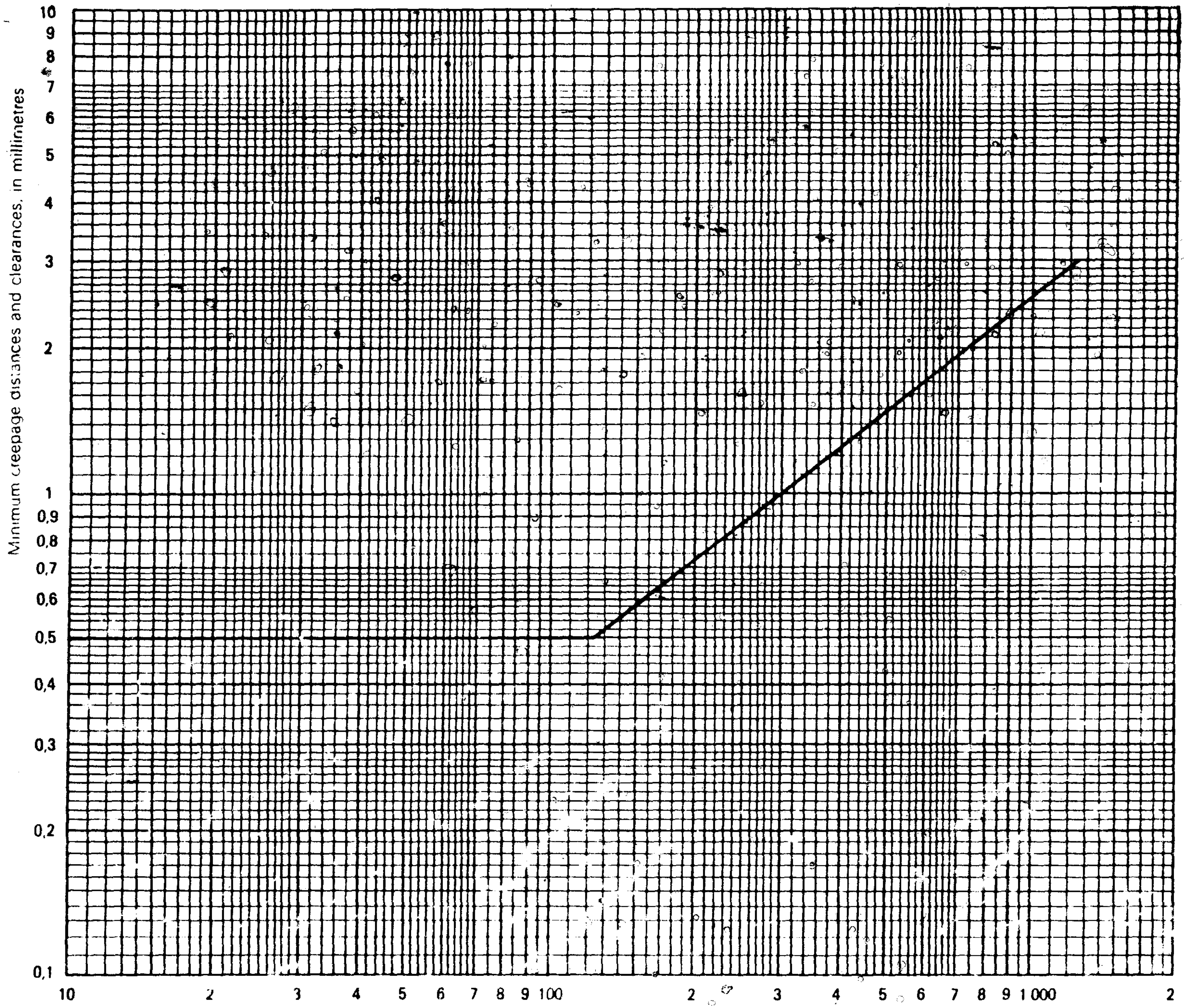
Ref.: Sub-clause 8.3.6.

FIG. 5. Scratch test for insulating layers.



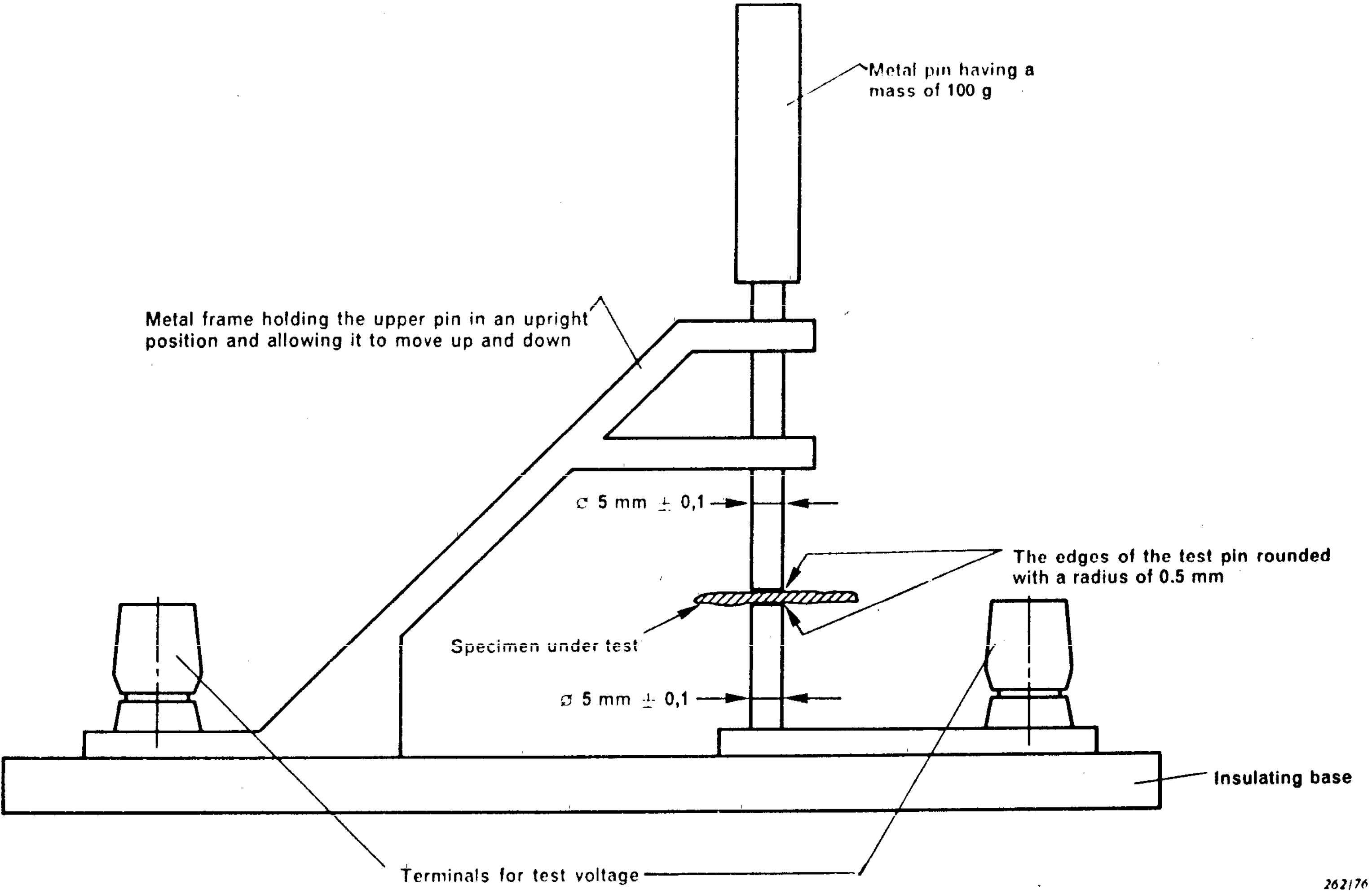
Ref.: Sub-clause 14.2.

FIG. 6. Testing device for apparatus forming a part of the mains plug.



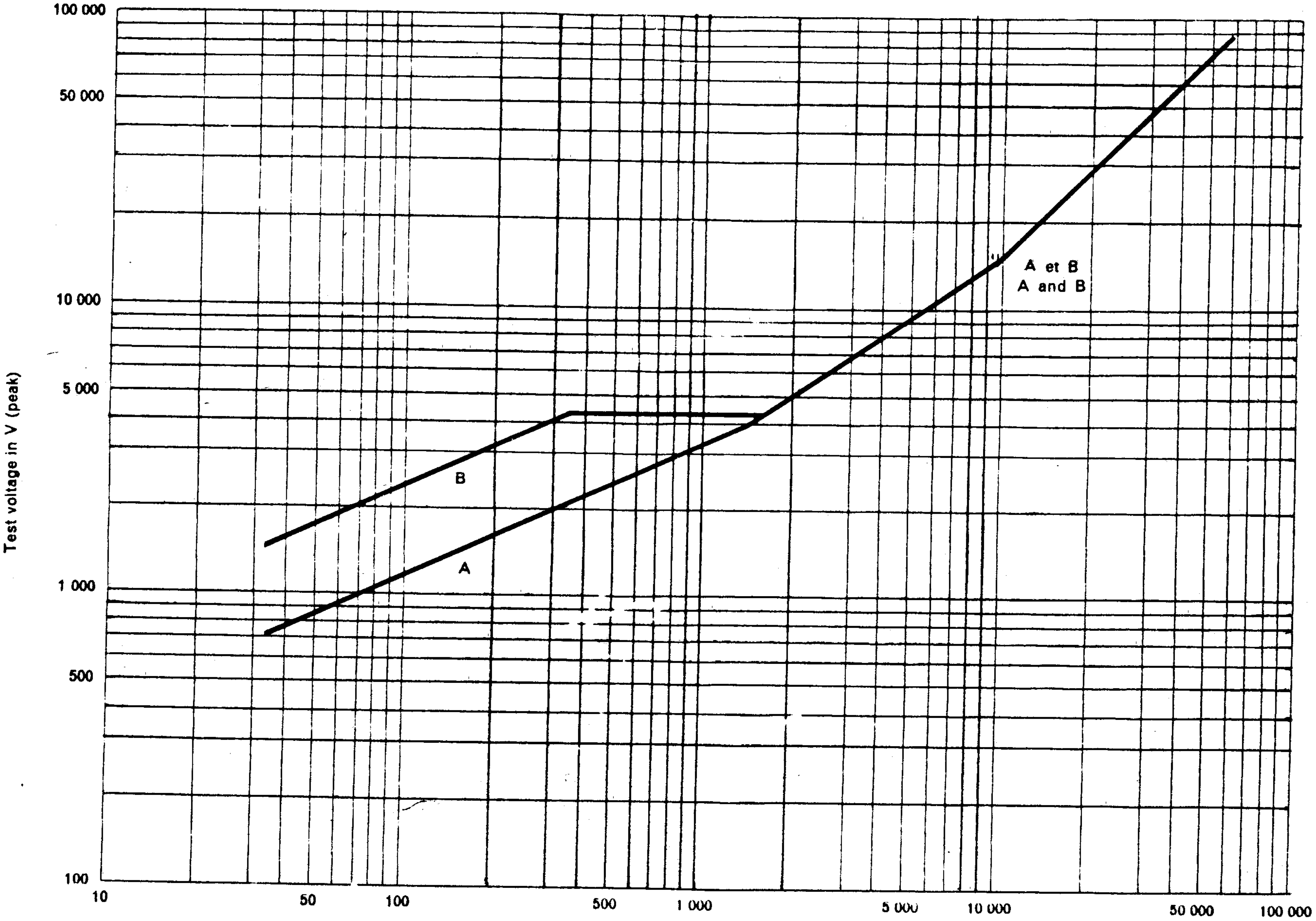
Ref.: Sub-clause [illegible]

FIGURE 7


Metal pin having a mass of 100 g
Metal frame holding the upper pin in an upright position and allowing it to move up and down
⌀ 5 mm ± 0,1
The edges of the test pin rounded with a radius of 0.5 mm
Specimen under test
⌀ 5 mm ± 0,1
Insulating base
Terminals for test voltage
262/76

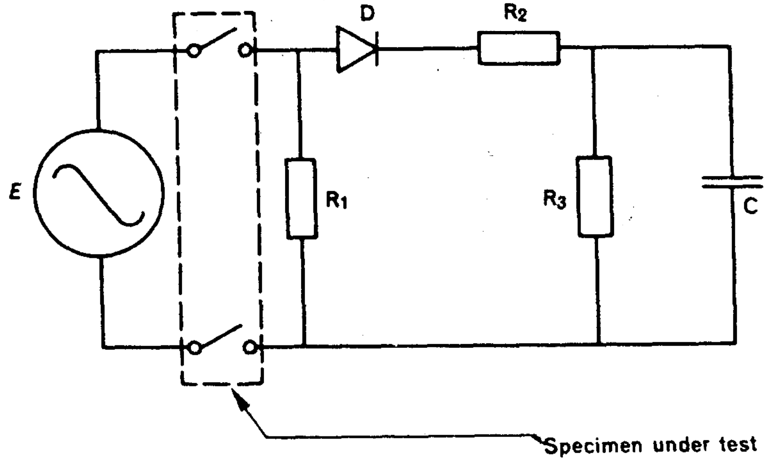
Ref.: Sub-clauses 9.2 and 13.8.2*a*).

FIG. 8. Dielectric strength test instrument.



Ref.: Sub-clause 9.2 – Table III

FIGURE 9



The circuit values are:

$R_1 = \frac{E}{I}$ where E is the rated voltage and I is the rated current.

$R_2 = \frac{R_1 \sqrt{2}}{X}$ where X is the ratio between the rated peak surge current and the rated r.m.s. current.

$R_3 = \frac{800}{X} R_1$

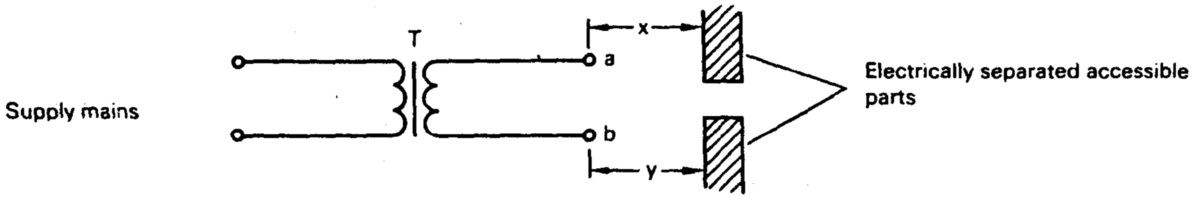
$CR_2 = 2\,500\ \mu s$

D = a silicon rectifier

The circuit elements and the source impedance are chosen so as to ensure a 10% accuracy of the rated peak surge current and the rated current.

Ref.: Sub-clause 13.4.2*b)*.

FIG. 10. Circuit for mains switch testing.



The diagram shows a separating mains transformer T, where point "a" is live relative to point "b". If "a" and "b" are inside the apparatus, the sum of the distances x and y is taken into account for the purpose of checking compliance with Sub-clause 8.3.4.

Reference: Sub-clause 8.3.4

FIG. 11. Example of assessment of reinforced insulation.

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